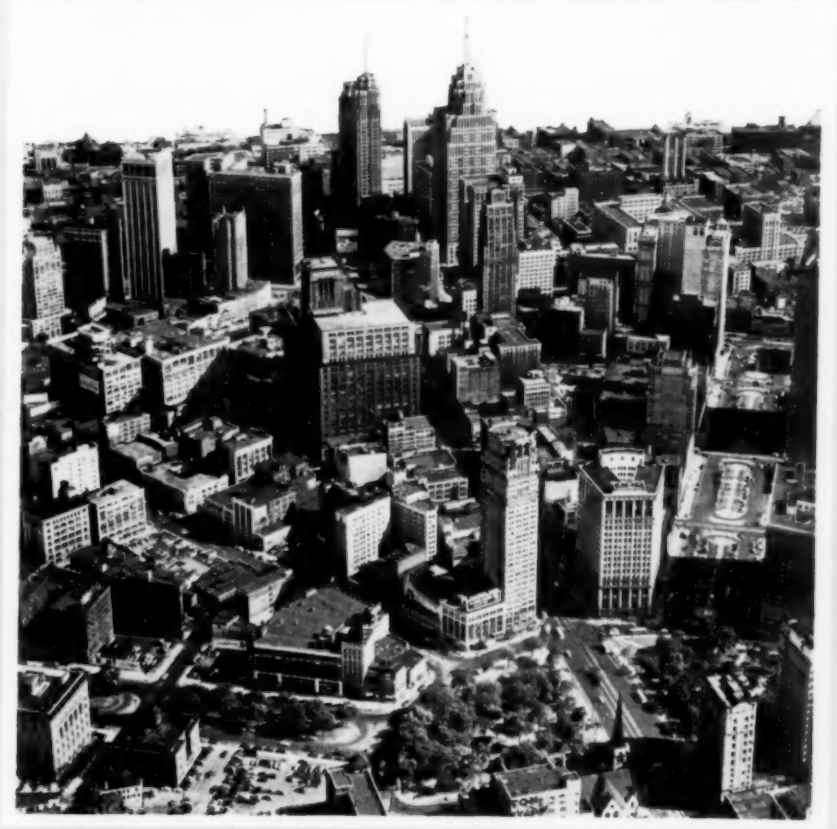
THE SOCIETY OF

PLASTICS ENGINEERS JOURNAL

"PROGRESS THROUGH PLASTICS ENGINEERING"

January 28, 29, 30, 31

— a view of Detroit Conference City



JANUARY 1958 • VOLUME 14 NUMBER 1

HOW'S THIS
FOR A GROWTH STORY?

How Tycoon Plastics Builds Profitably with H-P-M Injection Molding Machines

Not too long ago, Tycoon Plastics of Miami, Florida, was receiving shipment on their first H-P-M Plastic Injection Molding Machine—a 6/8-oz. machine illustrated below. Since that time, two more H-P-Ms have been added, including a 12/16-oz. and a 20/28-oz. machine. Growth such as this is not uncommon in the busy South. H-P-M has played an important part in the production growth of many companies like Tycoon. You, too, can standardize on H-P-M equipment for successful plastic molding . . . injection, compression, transfer, and the molding of reinforced plastics. There's an H-P-M for the job—and they're tops with molders in busy shops all over the world.

HPM 6/8 oz.

Nylon fishing rod guides and rollers, shot weighs 4 oz.

HPM 12/16 oz.

This is a 12-oz. machine molding Butyrate anchors in a 10-oz. shot.

HPM 20/28 oz.

An 18-oz. shot on this 20/28-oz. H-P-M molds polyethylene parts.

H808

Write today for Bulletin 5701-A describing HPM's complete line of plastic injection machines—they're built for real service.

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JANUARY
1958

DOW

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

EFFECTIVE CONTROL OF VARIABLES DEVISED FOR INJECTION MOLDING OPERATIONS

AUTOMATIC ADJUSTMENT IMPROVES QUALITY AND UNIFORMITY OF MOLDED PARTS

Frequent mention has been made in the past few years of using a pressure signal to control the operation of an injection molding machine directly from the plasticized zone. This would help to regulate the pressure and temperature sequence precisely and uniformly in the injection mold. Needless to say, a superior quality of molded parts would result.

Dow Plastics Fabrication engineers have examined several of the possibilities and have tested the following control on which U. S. Patent 2,786,234 was obtained.

The system used for controlling the injection pressure consists of: (1) an instrument placed in the mold to measure the plastic pressure; (2) a recorder with pneumatic control; (3) an air operated relief valve connected to the hydraulic line of the molding machine. Figure 1 gives you a graphic view of the installation of such a system.

With this automatic controller, setting controls becomes easier and time and material required to get the mold into production are saved. Flashing and short shots do not occur following an interruption in the normal molding cycle. Changes in material or viscosity are taken in stride without readjusting the controls. Finally, uniformity of piece weight is excellent.

This particular system works effectively on heavier types of moldings. But, to mold thin-walled parts where faster cycles are necessary, superior injection molding depends largely on the placement of the pressure transducer. Whether you consider placing it directly in the mold cavity, in auxiliary cavity, the runner system, or in the nozzle, each location must be thoroughly evaluated for its respective advantages and drawbacks.

The machine used in testing the effectiveness of the system was equipped with a weigh feeder whose accuracy was ±.6 grams of the granular feed. When molding this part on a conventional cycle, the variations in the weight of the part were ±.4 grams. But, by using the pressure control system, these variations were reduced to ±.16 grams. See these results in Figure 2. This is only one of a number of advantages to be derived from the pressure control system.

Plastiatrics studies and research continue in this area and similar fields in an effort to find practical solutions to problems in plastics formulation, design, molding and finishing. For your copy of our technical bulletin entitled "Pressure Control for Injection Molding Machines", write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Dept., 1518F.

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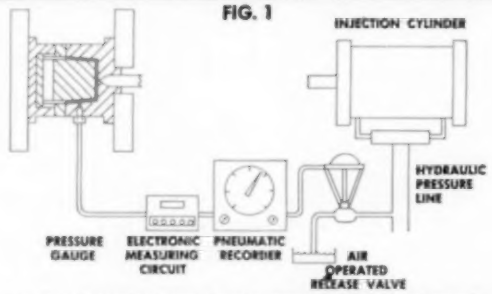
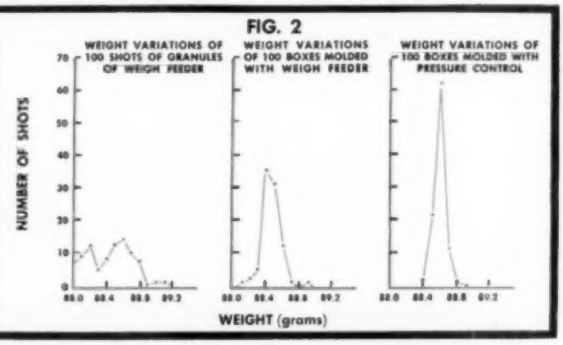
FIG. 1



PRESSURE CONTROL SYSTEM FOR INJECTION MOLDING MACHINES

FIG. 2


WEIGHT VARIATIONS OF 100 SHOTS OF GRANULES OF WEIGH FEEDER
WEIGHT VARIATIONS OF 100 BOXES MOLDED WITH WEIGH FEEDER
WEIGHT VARIATIONS OF 100 BOXES MOLDED WITH PRESSURE CONTROL
NUMBER OF SHOTS
WEIGHT (grams)

YOU CAN DEPEND ON DOW

SPE JOURNAL

VOL. 14 JANUARY, 1958 NO. 1

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DR. JESSE H. DAY

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Charles A. Chayne, vice president of General Motors Corp., will address the luncheon meeting at the SPE Conference in Detroit this January. More information about Mr. Chayne is on page 52.

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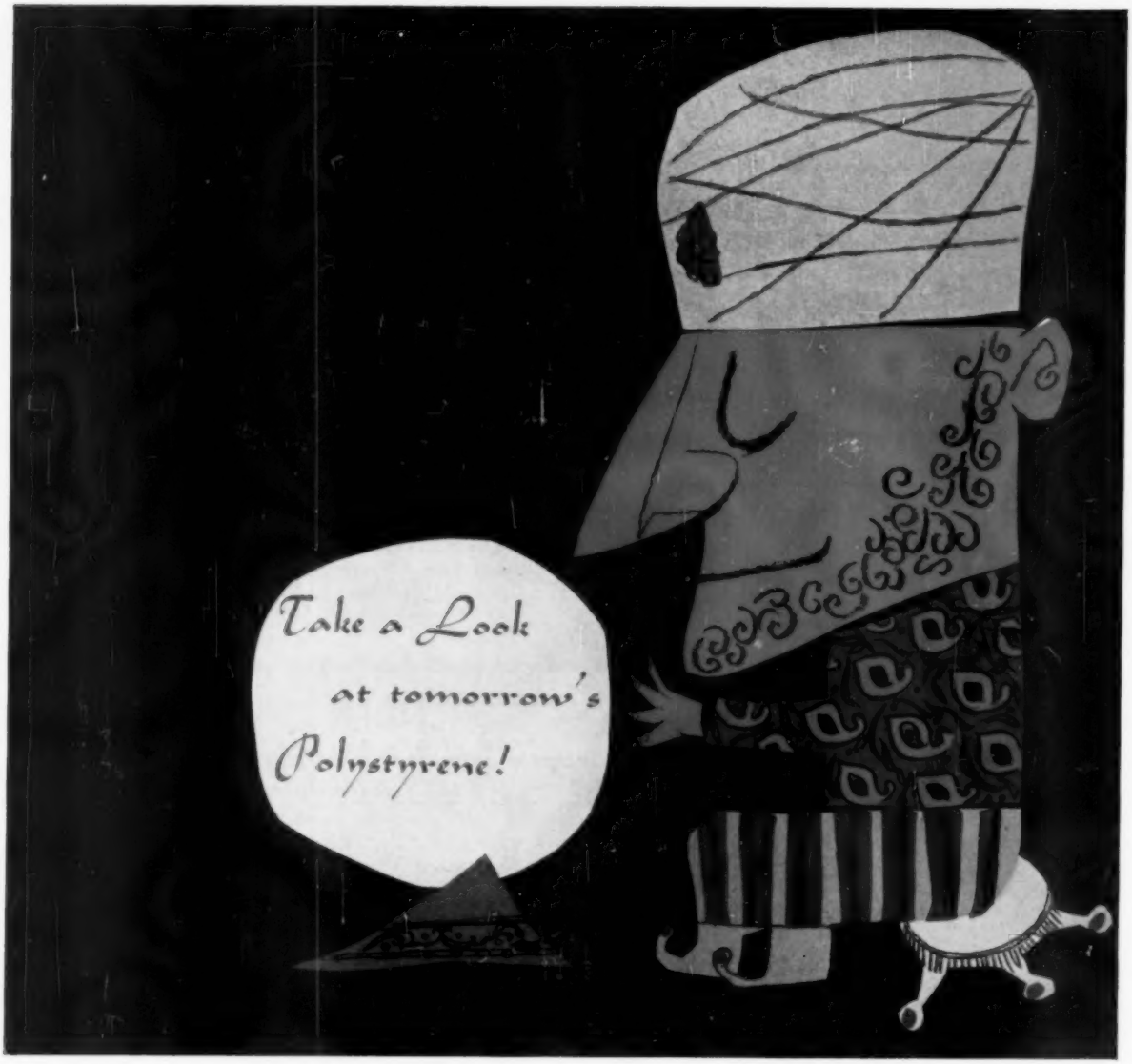

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From The Editor's Notebook

By JESSE H. DAY

One of the comments on Mr. McCann's challenging editorial of last month is given here:

Hiram McCann

I enjoyed your guest editorial in the SPE Journal. You brought up a good point. But what about vertical integration between the resin producer and the fabricator? Witness: Visking, Plax, Bolta, etc. Isn't the answer perhaps that plastic fabrication is relatively inexpensive, particularly in investment, while making resins and refrigerators requires large investments. Doesn't this pose a real threat to the small fabricator from both directions?

I wonder if SPE, SPI, MP shouldn't explore the problem so the fabricator will know which way the wind is blowing.

Best personal regards.

Roger Williams, Jr.

Roger Williams Technical and Economic Services, Inc.

Calendar of SPE Technical Meetings

ANNUAL TECHNICAL CONFERENCE

"Progress Through Plastics Engineering"

January 28-31, 1958 — Detroit

The Hotel Sheraton-Cadillac

98 engineering and scientific papers on all phases of the plastics industry, including research and education —
Chairman: C. H. Whitlock, 21655 Coolidge Road, Oak Park, Mich.

—Program—page 49

CHICAGO RETEC

"New Developments in Injection Molding Techniques"

April 18, 1958 Conrad Hilton Hotel

Write for further information to the Retec Chairman, John Adams, Eastman Chemical Products, Inc., 4200 Dempster St., Skokie, Illinois.

This Month's Cover:

The new cover design this month provides the Journal with a more readily identifiable cover, which states quite plainly that plastics engineering is our field, and which sports our present SPE emblem in place of the outmoded one. We sincerely hope you like the change. It is just one step in a continuing program of growth.

The photo, of course, is our convention city for 1958, and this is the view enjoyed by birds and airplane passengers as they look south across the city toward Canada.

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Pro-fax is the second of many new polymers resulting from a Hercules research program designed to explore the chemical horizons opened by the development of organometallic catalysis systems. Others will follow as Hercules continues its leadership in the important field of polyolefin chemistry.

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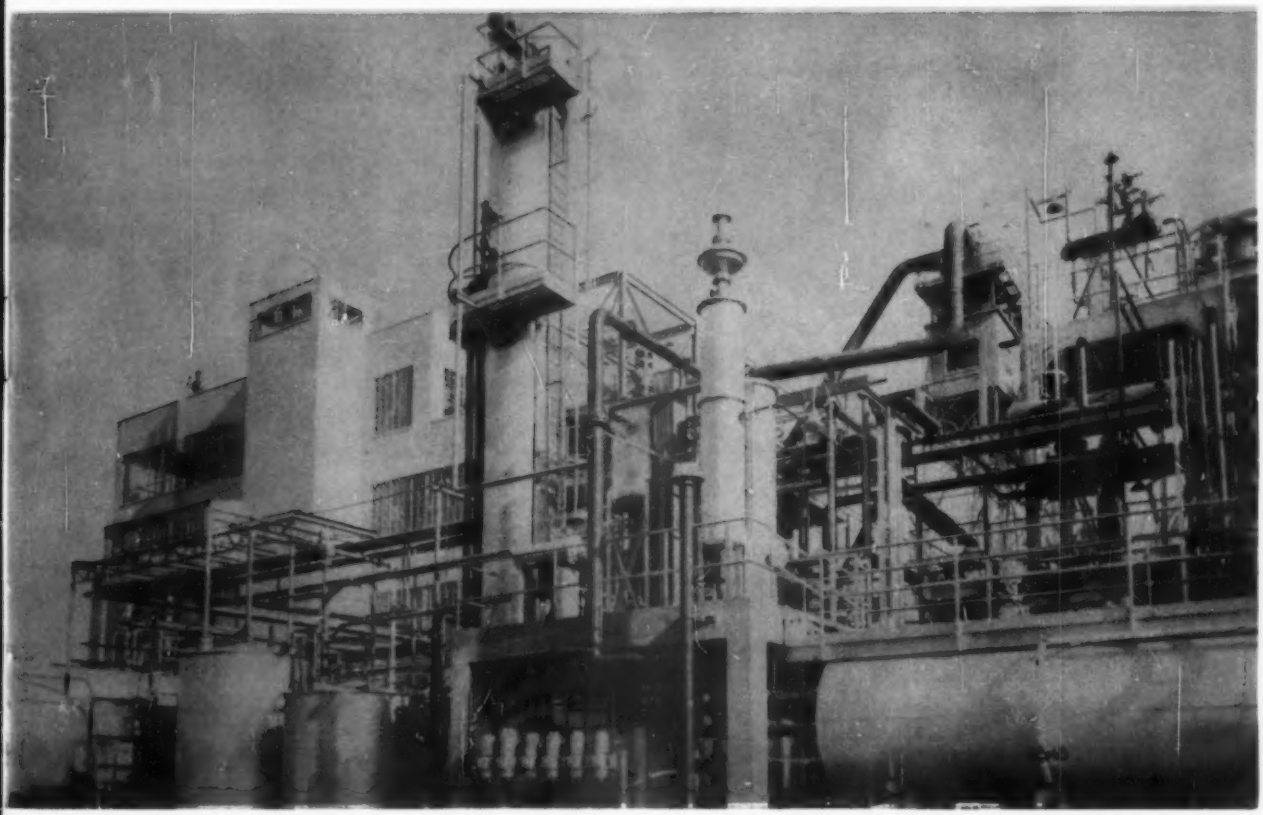

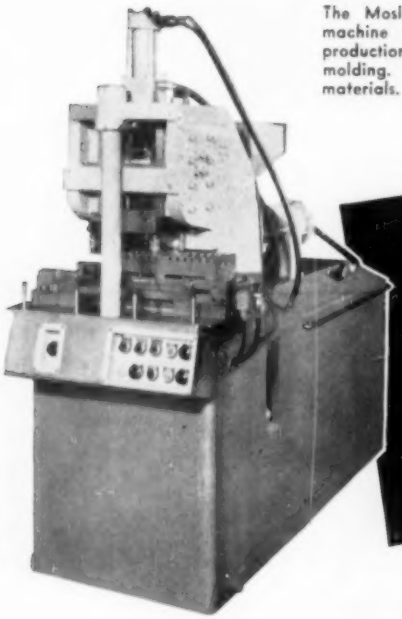

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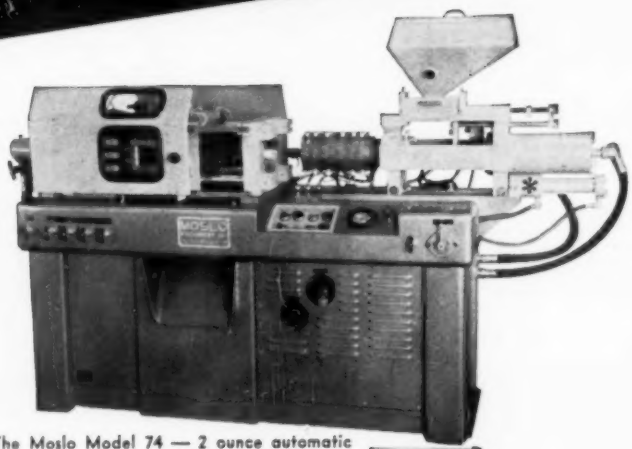
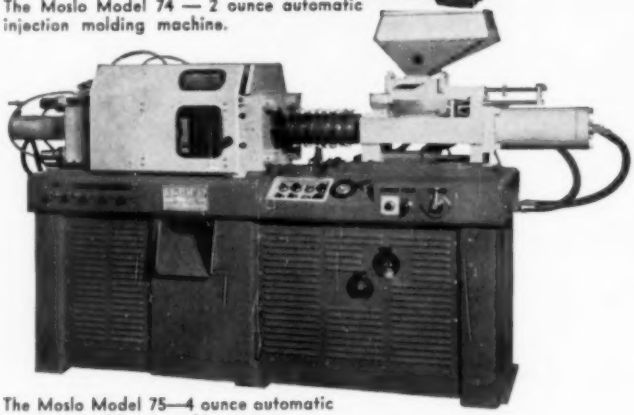


The Moslo Model 74 — 2 ounce automatic injection molding machine.



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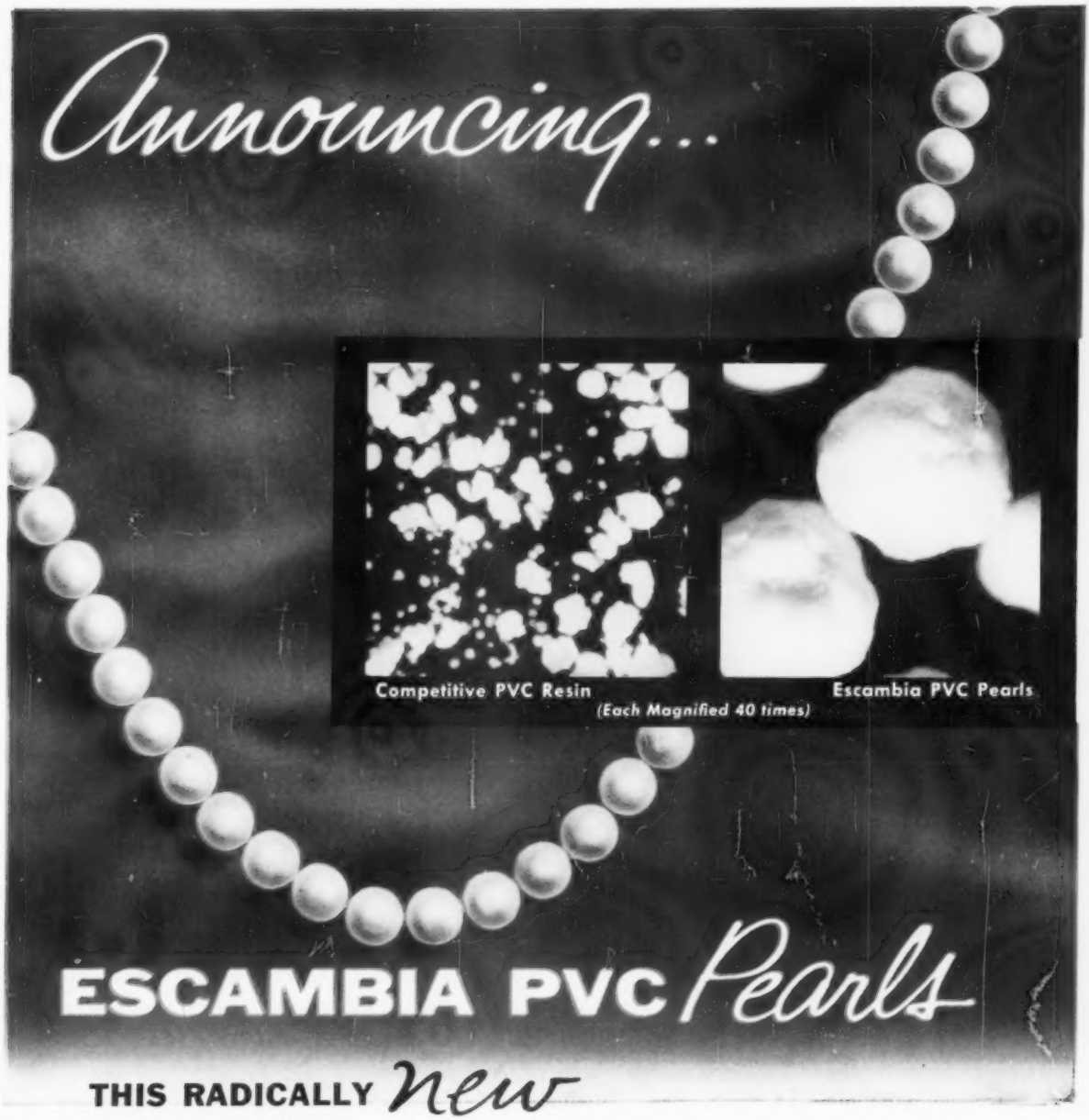

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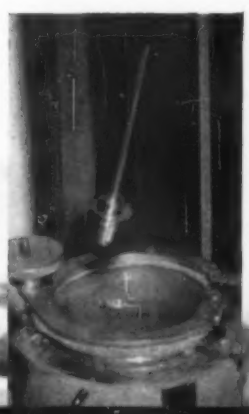

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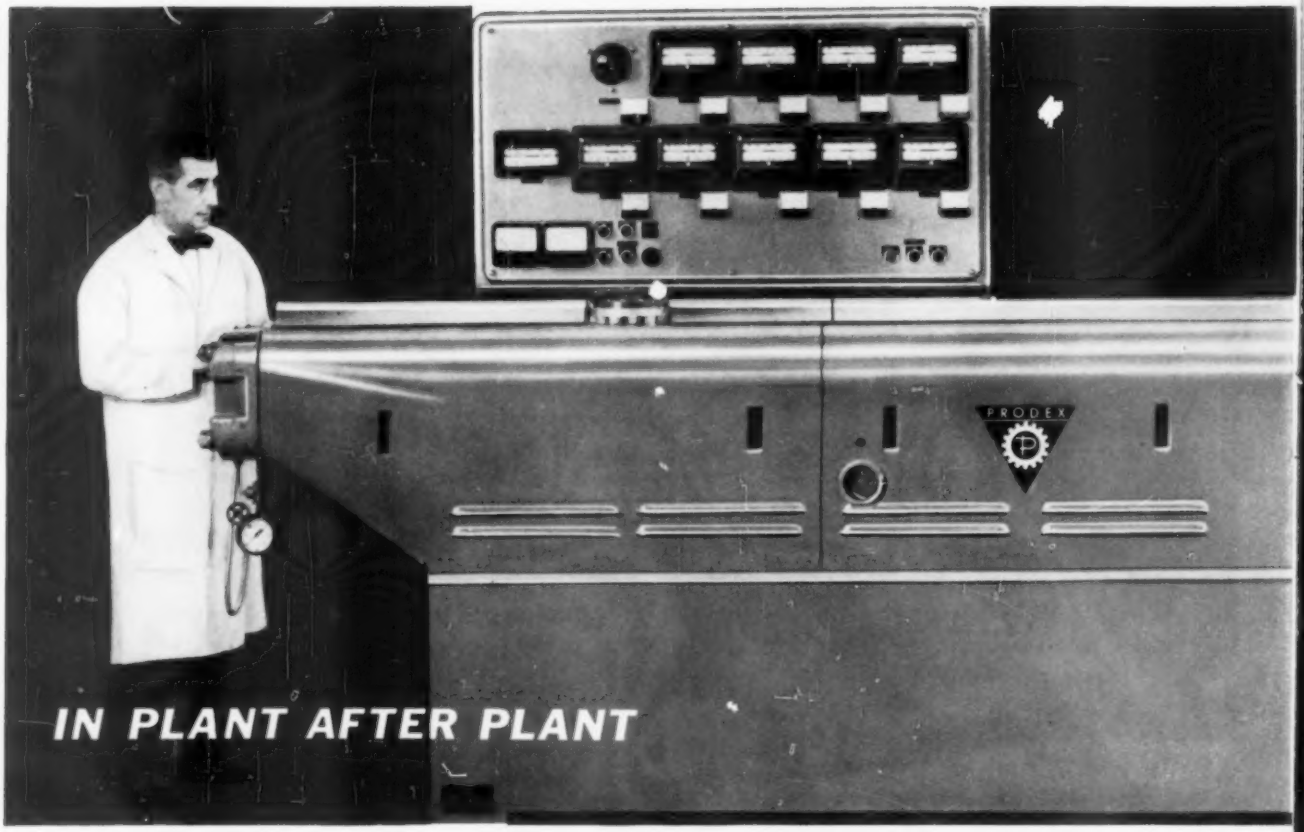

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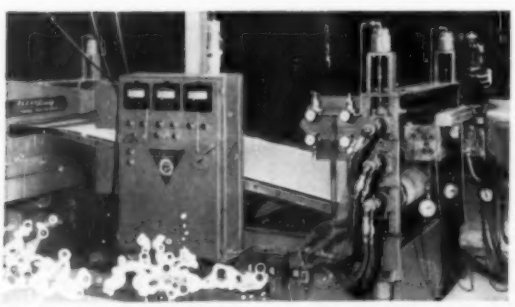

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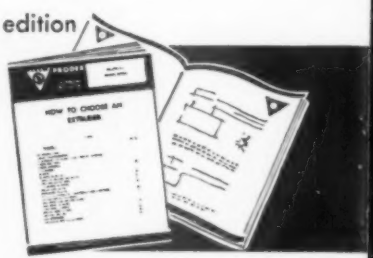

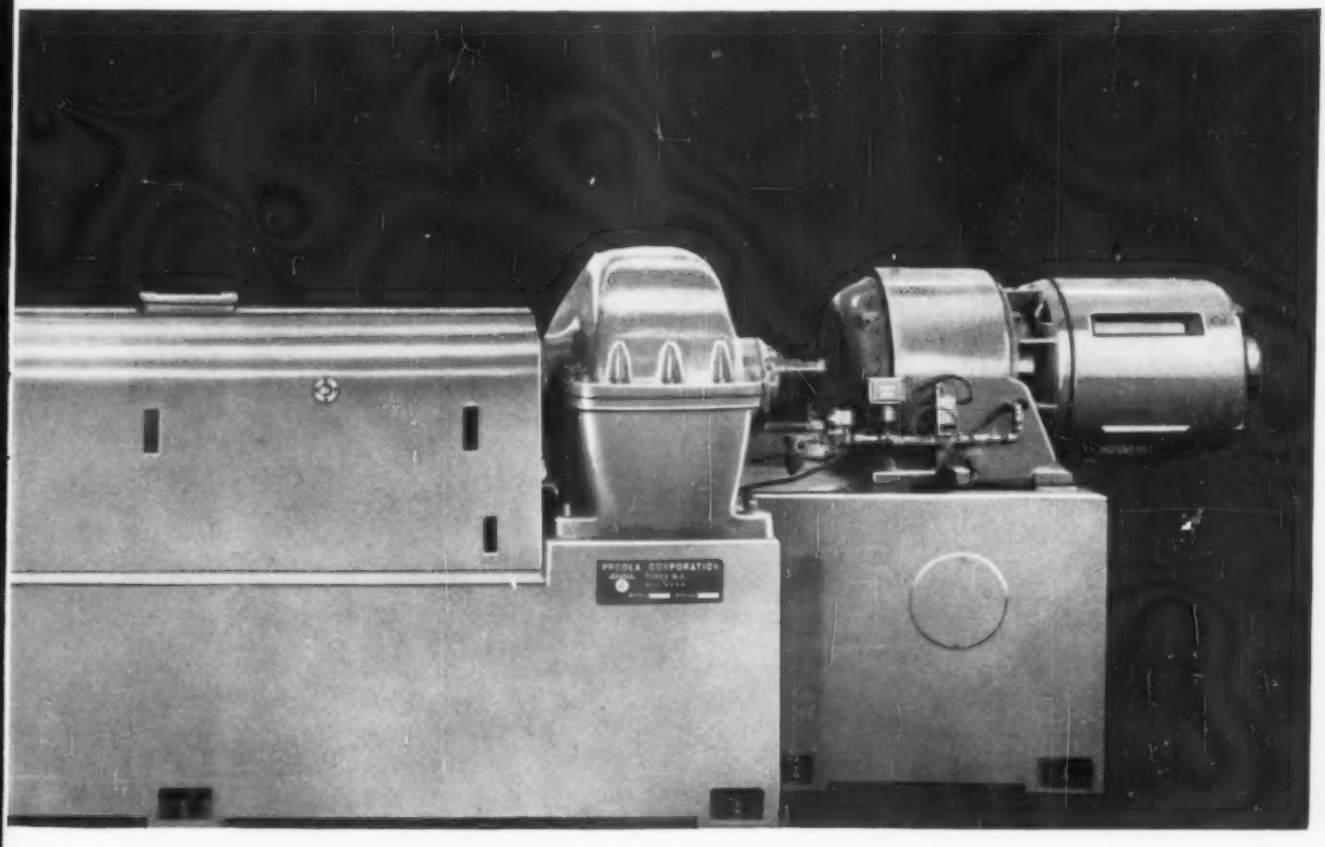

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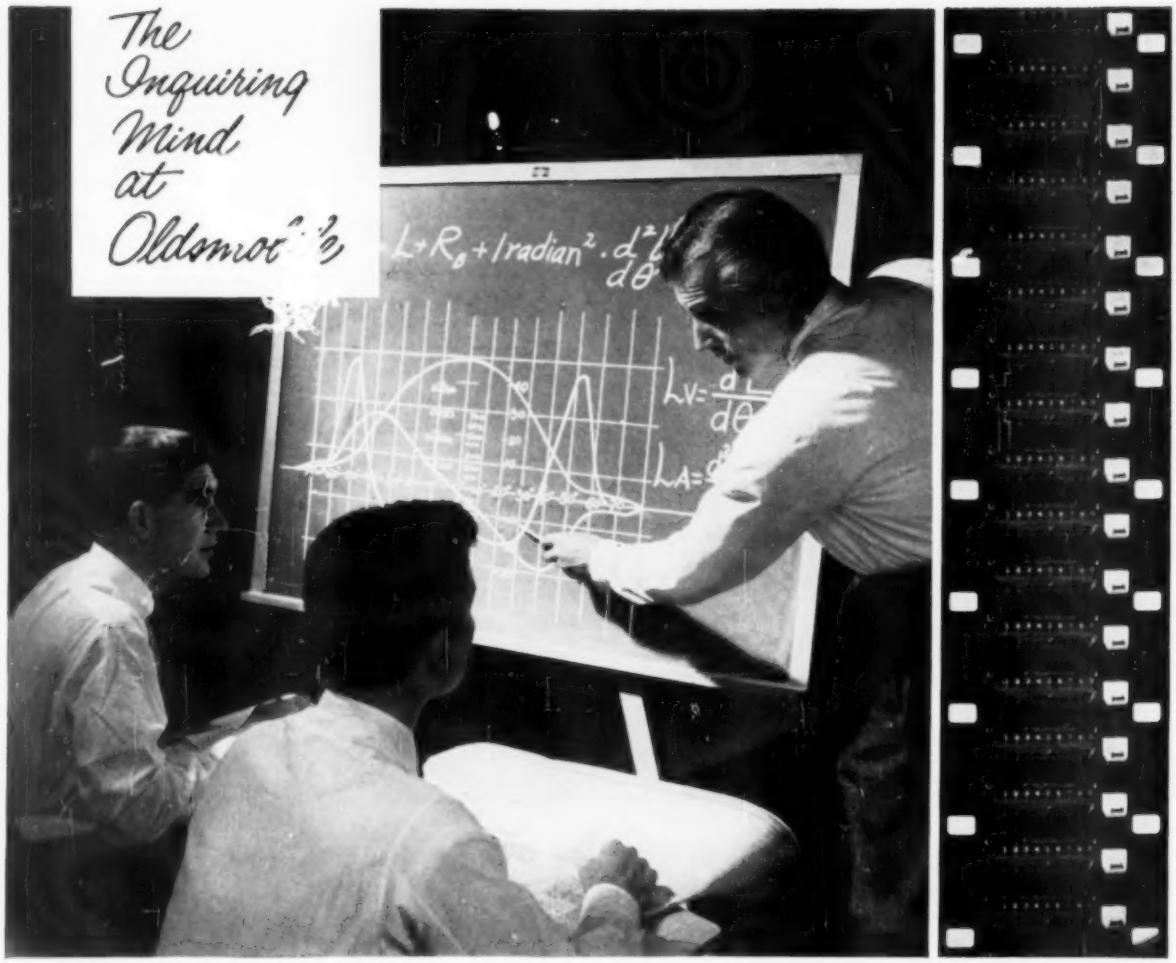

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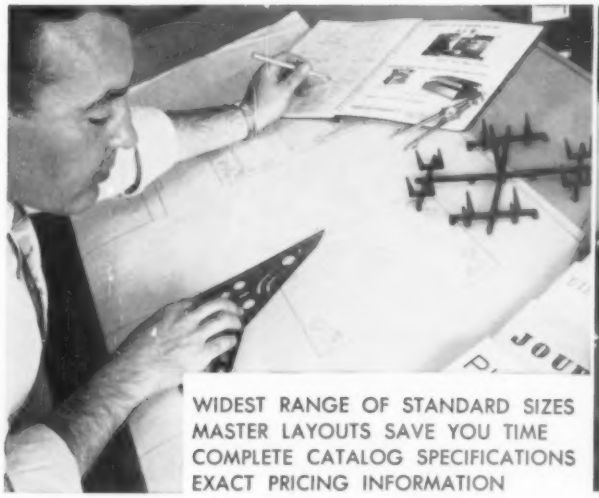

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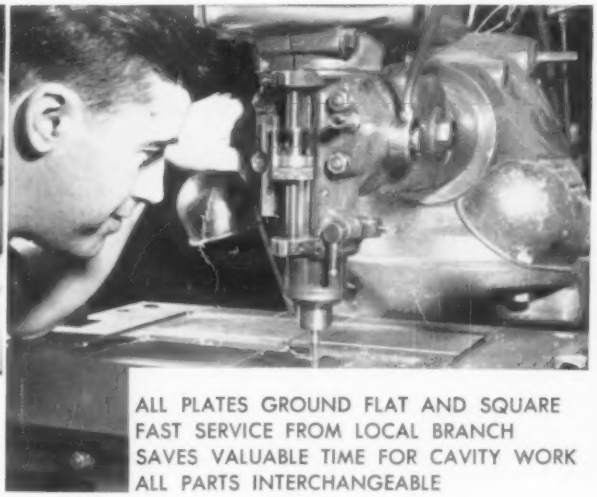

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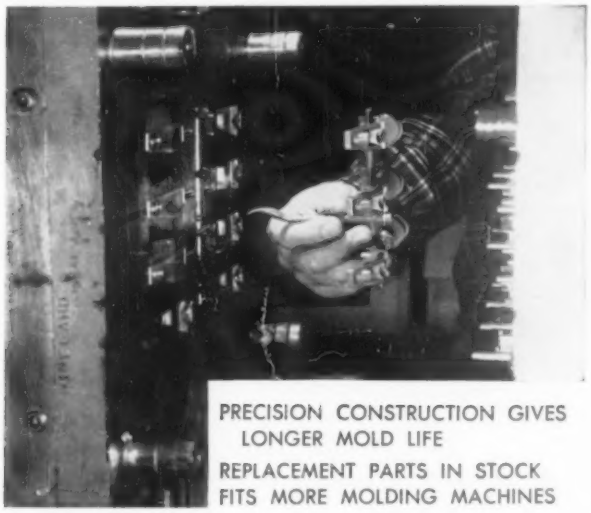

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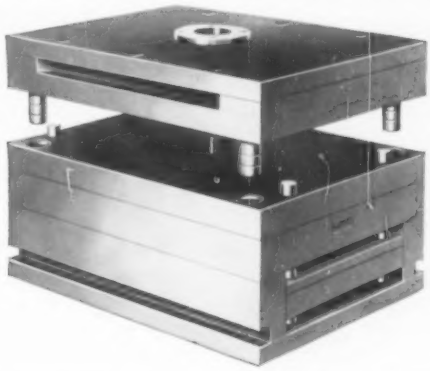

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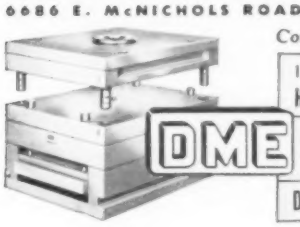

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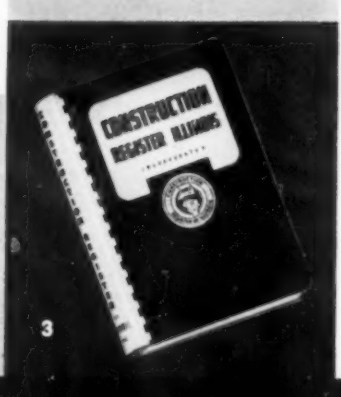

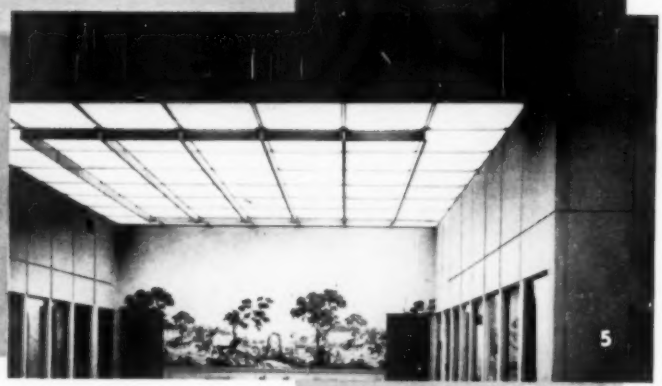

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Some Problems in Developing a . . .

High Tolerance Precision Laminate

M. R. Levy

Raytheon Manufacturing Co.
Wayland, Massachusetts

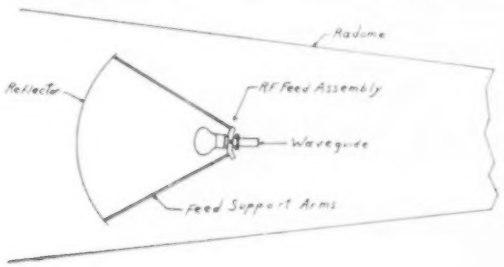


Figure 1. Horn cover with radio frequency window.

This paper discusses the use of a high tolerance precision laminate for a pressure housing over the primary radiator of a radar reflector. As can be seen from Figure 1, one of the functions of the horn cover is to provide a radio frequency (RF) window and a pressure seal for the air in the waveguide leading to the radar system. It is necessary to maintain atmospheric or higher pressure in the waveguide to prevent high power breakdown between the walls of the waveguide. If the cover were not present the air in the waveguide would exhaust into the radome at the lowered atmospheric pressures that exist at high altitude. The other important function of the cover is to prevent corona. To do this the cover must be spaced far enough away from the horn mouth so that the field strength is reduced below the point where corona will form.

Therefore it is necessary to design the cover with regard to three criteria, RF considerations, environmental conditions and manufacturing considerations. Since it is apparent that the cover is another parameter with regard to RF, the horn was designed to give optimum RF beamwidths without the cover. Then the cover was designed to present minimum interference with the radiation pattern of the horn. If necessary the combination is then redesigned for optimum performance. This approach immediately led to two conditions which made the job very difficult. Tests proved that to provide minimum interference with the radio frequency energy, the wall thickness had to be held to 15 to 17 thousandths of an inch, and also that the shape had to be an oblate spheriod. This led to it being nicknamed the "football" horn cover. This shape was necessary since it was found that edge currents flowing back over the mouth of the horn feed would interfere with the primary pattern unless the angle of the back of the horn cover were very carefully adjusted. This oblate spheroid shape made the mold problem difficult since the reverse curvature, which can be seen in Figure 2, made it necessary to make the mold in five parts.

This paper was presented at the New England SPE Retec, June, 1957.

Since the cover is located in a high performance aircraft it must withstand rigorous environmental conditions. In this case sub-zero to about 300°F was the range of performance. To understand the effect of environment on the part it is best to analyze the conditions in the aircraft during and before flight. Before flight, the airplane may be stored at sub-zero temperature. Shortly after this it may be climbing rapidly and approaching the speed of sound. If this happens the temperature goes up due to the ram effect of the aircraft pushing through the air, and the pressure differential becomes greater inside the cover due to the drop in atmospheric pressure outside the cover. Some way had to be devised to simulate realistically these conditions so that tests could be performed to insure reliability. The method chosen was to test the cover by means of a pressure

Figure 2. Spheroid shape with reverse curvature required a five part mold.

cycling apparatus (Figure 3) which is a simple device consisting of solenoid valves operated by a 1 rpm motor. This device cycles the horn cover twice a minute from 0 to 20 psig in a gradual manner to avoid pressure shocks. The second step in the test is to subject the cover to an elevated temperature of 270°F under a static 20 psig. The best method for detecting leaks under these conditions is to seal the horn off after the pressure has reached 20 psig and to place the unit in an oven at 270°F. The leak can then be detected by a drop in the pressure in the closed loop which includes the horn cover. This test method realistically simulates the environment in that the cycling twice a minute imitates the climb of the aircraft from ground level to high altitude flight. The oven test at 20 psig resembles prolonged flight at supersonic speeds.

Failure Through Voids

The parts at this time were bag molded and then assembled on the laminated glass wrapping around the mouth of the horn as shown in Figure 2. Using the aforementioned testing method, the initial result was one failure after another. These failures were occurring in the region of the football and about ninety percent were occurring under high temperature test. It was found that the commercial resin we were using, which was rated for 500°F operation, was softening under the 20 psig pressure and failures were occurring through small pin hole voids in the laminate. The more commonly used high temperature materials such as phenolics could not be used in this case due to poor electrical characteristics at microwave frequencies. As can be seen in Figure 4, a typical failure occurred as the resin softened at 260°F. The remaining air then forced its way out through the voids in the laminate enlarging them as it passed through. One thing was determined at this point, and that was for reliability purposes a derating program was necessary. The method followed was analogous to that used with any other electronic component. In this case to take the ultimate temperature rating of a resin and derate it by about 40%. Actually this is really a necessity since the temperature rating of most resins are on the basis of standard tests which really do not apply here due to the multiplicity of interdependent parameters.

The resin was then changed and the majority of voids eliminated by changing the curing cycle of the part and carefully degassing the resin prior to layup. An epoxy spray coating was used to provide an additional pressure seal. A testing program was then initiated which allowed the cover to be tested alone without the horn. This was done to isolate the causes of failure. As is so often true when one weak point is eliminated the next weakest point fails. In this case the glass wrapping around the mouth of the horn delaminated from the magnesium horn. This problem was solved by bag molding the first layer of the wrapping to the horn with a high temperature epoxy and curing it. The rest of the wrapping was added later and then the horn cover was cemented to the horn and the outside wrapped with a few layers of cloth to reinforce the flat sides of the cover. At this point we began to get reproducible parts.

Summary of Principles

Summing up: five principles should be used in designing a precision laminate for use in a rigorous environment.

1. In a preliminary study determine what the purpose of the part is and what are the determining design parameters that cannot be changed regardless of manufacturing difficulty.
2. Determine the limits of the environment to which the part is going to be subjected. Also determine the time relationship of these environmental limits. Does the part have to withstand high temperature and pressure at the same time, or are there two distinct limits which are applied at different times?
3. Establish some method for realistically simulating these environmental conditions in the laboratory. This is a must for designing into the part any long-term reliability.
4. Establish a derating program for materials. Derate in direct proportion to the number of unknown environmental conditions. You can always ease up on these requirements later after successful parts are produced.
5. Use very careful quality control measures as regards to degassing the resin, and the inclusion of foreign material in the laminates.

In conclusion, I should like to acknowledge the help of Philip H. Dyer and A. Rodriguez who performed most of the testing and manufacture upon which this paper is based. ★★

Figure 3. Pressure cycling apparatus for tests of horn cover.

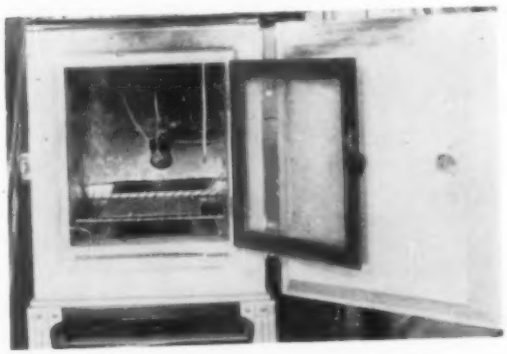
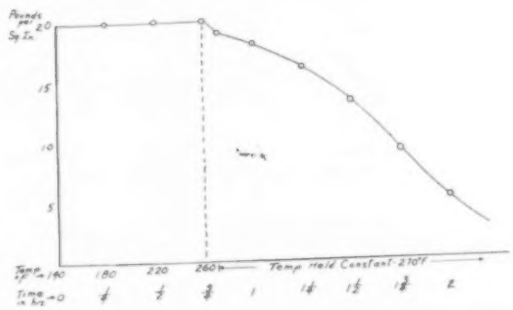


Figure 4. Temperature-pressure test on microwave horn cover of 0.015" polyester-glass laminate.



Higher Density Polyethylenes

George H. Sollenberger

Koppers Co., Inc.
Monaca, Pennsylvania

. . . the physical and chemical properties of the higher density polyethylenes make it attractive for a great number of applications . . .

When we refer to higher-density polyethylenes, we think of densities of 0.941 to 0.965. These figures are intentionally high. Density value of a sample "as received" will be lower than that taken after the sample has been annealed for one hour at 250°F. The value for an injection-molded specimen will be lower than that for a compression-molded sample which was cooled slowly over a 45-minute period so that it could develop a greater crystalline growth and hence higher density. We have found that this treatment is necessary for reproducibility, and such procedure is being incorporated into the ASTM polyethylene specification — D1248 — which is now under revision.

Stiffness Modulus

The high stiffness modulus of the higher-density polyethylenes can be directly related to the density. Here, again, variable test conditions can result in contradictory published data. Using compression-molded specimens which are ⅛" thick, the stiffness modulus range for the higher-density polyethylenes is 71,000 - 117,000 psi. This can be compared with roughly 20,000 PSI for the lower-density types. If the tests should be based on ¼" instead of ⅛" specimens, the higher-density readings jump to the range of 90,000 - 140,000 psi, and published data may be based on **either** of these procedures.

Tensile Strength

Similar confusion can occur when one considers the high tensile strength which is characteristic of the higher-density polymers. In many cases, the reported figure is the stress at the **yield point** on the stress-strain diagram rather than the **ultimate tensile strength,** which is the stress at break. Of these two, the yield point is generally regarded as being of greater technical value. Published data may be based on 20", 10", 2" or 0.2" per minute rate of cross-head separation, and the tensile reading will be higher at the higher rates, while elongation is an **inverse** function. We believe that testing at 2" per minute provides the most informative data, and compression-molded specimens at this rate show yield points of 3200-4400 psi for higher-density polymers. Injection-molded specimens, presumably because of orientation, usually show higher yield point readings which go up to 5500 psi.

Heat Resistance

The improved heat resistance of the higher-density polymers can also be related to density. The lower-density type shows Vicat softening temperatures of 175-212°F with the higher density type at 250-283°F, depending on average molecular weight. The crystal melting point for lower-density materials is about 229°F as opposed to 264-278°F.

While on the subject of heat resistance, it might be well to mention that mold shrinkage (injection) is 2-4% and that after-shrinkage at 200-250°F can be 2-4%. The higher the temperature, the shorter the time. The **overall** shrinkage is 4-6%, because parts which display high mold-shrinkage will usually show low after-shrinkage, and vice versa. Naturally, if dimensions should be critical, the total shrinkage must be considered in the design of parts which will be subjected to elevated temperatures in service.

Impact Strength

In the higher-density resins one can expect lower notched impact strength, indicating greater notch sensitivity than with the lower-density types. Notched IZOD values can range from 0.5 up to 10.0 ft-lbs. for various types. Average molecular weight exerts a strong influence on impact characteristics with, as one might expect, the higher impact strength being coupled with higher average molecular weight. Another variable is the thickness of the specimen being tested. One-half inch specimens will give lower impact strength values than one-eighth inch specimens and published data cannot be directly compared if different size specimens were used.

This paper was presented at the Cleveland-Akron Regional Technical Conference, October 1957.

Moldability

Processing characteristics of the higher-density polyethylenes are fully comparable to those of other ethylenic polymers, and selected types are available with melt indices from 0.1 to 10.0. Here is another region of possible confusion. Polyethylenes of identical melt index from several producers may not have the same average molecular weight distribution and hence may require radically different processing conditions. The viscosity-temperature cures of these materials may be completely dissimilar, but they just happen to intersect at the 190°C temperature which is used in the melt index determination. Obviously, one point cannot define a curve.

Environmental Crack Resistance

Environmental crack resistance is definitely related to density, although it is also a function of average molecular weight distribution. Higher-density polyethylenes of high average molecular weight (low melt index) have demonstrated excellent crack resistance when exposed to cracking accelerators such as detergents. A third factor is the state of the crystallite component of the specimen being tested. If the crystallites are small and numerous and if the growth to spherulites has been suppressed by rapid cooling or by the incorporation of a growth inhibitor, crack resistance will be improved. A fourth and very important consideration is the degree to which the specimen being tested is free of stress. In this instance, it is possible to have high internal residual stress resulting from molding conditions. It is also possible to have a high stress resulting from externally applied load. Examples would be bent wire or pressurized pipe. In any case, the presence of stress can be highly detrimental.

In all probability, it is a combination of these and other factors which cause the lack of inter-laboratory reproducibility of the well-known Bell Labs test and the recent abandonment by ASTM Committee 0-20 of this test procedure in its original form. Of course, since this property is of great importance, the search continues for a reproducible method for its measurement.

All this adds up to one conclusion: laboratory data can be very valuable when properly used, but it is seldom that laboratory test procedures will simulate service conditions. Furthermore, published data can be honest and misleading at the same time. The final proof, of course, is to try the several competitive materials in the actual part under actual service conditions.

Applications

It appears that film will be one of the major outlets for the higher-density polyethylenes, and it also appears that there will be very little competition with low-density film. The clarity, stiffness, heat-resistance and very low permeability of this high density film should enable it to do a superior job in fields where cellophane and foil are now being used. Sterilizable pouches and freezable-cookable packages offer interesting possibilities. Water-quenched flat film is clearer than tubular film, although they both exhibit good tear strength when torn across the machine direction, due to orientation, and only moderate strength when torn parallel to machine direction. It appears that bi-axial orientation might be an excellent solution. Materials down to 0.5 melt index have been processed into film, but low melt index types do not display optimum draw-down characteristics. There is no blocking, and the film handles well in commercial bag-making and over-wrap machinery.

Filament

By way of contrast, the best filaments are being made from low melt index materials in the range of 0.4 to 0.6. This is a somewhat different case than that of film draw-down, however, because it is the orientation from the **secondary** draw-down that is responsible for the 70-90,000 psi ultimate tensile strengths of commercial filaments. So far, rope has been the major outlet, but work on smaller diameter filaments for fabrics is progressing rapidly. Special formulations are available which provide improved crush resistance and excellent outdoor weathering properties.

Coated Paper

In the case of paper coating by extrusion, the problem of draw is even more critical than in the case of film. Not only must the hot web draw down to the required thickness, but it must do so under temperature conditions which provide adequate adhesion to the substrate. The coating of cloth or paper with 7-10 melt index materials is relatively straight-forward, but adhesion to cellophane and foil leaves something to be desired and work is continuing. For coated paper, the strong points of the higher-density polymers are the same as those mentioned previously for film, plus abrasion resistance.

Blown Items

Producers of bottles and other blown items are primarily interested in the low permeability and good environmental crack resistance of the higher-density polymers, although the heat resistance and rigidity are of importance in specific applications. Bottle-blowing techniques parallel those used for lower density polyethylenes, but experience has shown that the air injection schedule is somewhat more critical with the higher-density types. Late air injection can result in an "orange-peel" surface, because the surface of the tube has begun to cool. Early air injection can cause flashing. Optimum conditions will result in an almost perfect reproduction of the mold surface. On the basis of environmental crack resistance, material selection is usually the lowest melt index which the equipment can handle efficiently.

Sheet

Similarly, the strongest, toughest extruded sheet is produced from higher-density polyethylenes of low melt index (under 1.0). Sheeting which is made under conditions of zero draw-down is stress-free and does not distort when reheated. In general the extrusion of sheet with subsequent hot-roll polishing follows usual procedures. Some technique modifications are required for thermo- forming higher-density polyethylene sheets, because the hot sheet has virtually no "body" or hot-tenacity. Work on this problem is going forward rather rapidly, because it appears that sheet represents a large-volume potential for the higher-density polymers on the basis of cost, stiffness, and heat resistance.

Pipe

In the field of pipe and tubing, the heat resistance, environmental crack resistance and tensile properties of the higher-density polymers are of interest. Production of pipe from low melt index polymer (under 1.0) is not difficult by either the internal or external sizing methods. Threaded fittings look good on the basis of test installations, but a large amount of work remains to be done on collection of data to establish maximum safe temperature and pressure combinations. The potential market in the dairy, food process, beverage, and chemical industries can

(Please turn to page 64)

Printed Circuitry in Automobile Design

V. R. Herterick

Ucinite Co.
Newtonville 60, Massachusetts

. . . the use of printed circuits for instrument clusters gives the automobile designer decided advantages—and provides the plastics industry with new opportunities and new markets . . .

With the introduction of the 1957 Oldsmobile, printed circuitry hit the automotive industry with an apparently sudden impact. This technique applied to instrument cluster wiring, has caught the fancy of technical and lay personnel alike.

Actually, the adaptation of this type of circuitry was much slower and more evolutionary than most suspect. Without fanfare, small printed circuits have been substituted for metal-plastic combinations in gauges, meters, and signaling devices for more than a year. The substitution for conventional wiring in automotive radio has also gone almost unnoticed. In such electronic devices as the automatic headlight dimmer, printed circuity has been a factor in design for a considerable period. Now, however, the use on the instrument panel causes a greater awareness of the potential of this process than ever before existed.

Printed circuitry or printed wiring; either term has come to cover just about any method for applying an electrically conductive pattern repetitively to an insulating surface.

Production of Printed Circuits

At the present time, there are more than a dozen ways of commercially producing such parts, yet almost all of these fall into two categories. There are those that are primarily electrochemical, and there are those that are essentially mechanical in nature. In the electrochemical category, we include the most popular process; that of etching a pattern on a copper clad laminate. Also included are electrical deposition, printing, chemical reduction, transfer plating, and vapor deposition. The mechanical processes include the various forms of die stamping, as well as spraying, powder pressing, abrasion, and those processes calling for stamping on molded shapes, where the molded piece provides a die function.

This paper was presented at the Detroit Section SPE Third Annual Conference.

So strongly do we feel that each process has its own rightful place, that we, in our own corporate structure, have plants geographically separated and devoted to the two basically different categories. Pattern precision, circuit complexity, controlled electrical characteristics such as resistance and inductance all might tend to justify the higher cost processes, but the automotive low voltage electrical system puts more emphasis on ruggedness, durability, high current load and low cost. All of these are not only available in mechanical processes, but tend to be characteristic of them.

Application Potential

The application potential in the modern passenger car should probably be divided into three categories. There is first of all the replacement of some small wiring harnesses. It is this approach that is best represented in the conversion of a typical instrument cluster. Another major area is in the design of electrical components such as switches, terminal boards and connectors. The third category is the potential of electronic devices themselves. The radio is one, but the recent parade of headlight dimmers, convertible top operators, and the like, indicates that the field is just opening. Electronic circuit designers have long been aware of the benefits of printed boards in reducing the complexity and size of a unit. So the entry of the process through the use of such devices was natural, and will surely continue.

Anything that could have eliminated the maze of wiring and hardware that dangles behind the modern dashboard would have provided an improvement, but more important than that it contains many of the keys to the future of the process in our industry. In automotive design space is money, particularly as engineering and styling advances place it at a premium. The largest instrument panels, particularly those expanded to include accessories, indicators, and switches, have been in complete conflict

with the need for space reduction and in some models an impasse was rapidly approaching.

But space is only the beginning. The very elimination of the maze of wiring makes for greatly improved reliability. Cable chaffing, straining and shorting are gone. Terminations and splices, well-known trouble spots, are unnecessary. The fool-proof method of assembly makes for greater quality, not only in the original installation, but certainly in service. Speaking of service, the key word, of course, is "accessibility" and this is an important characteristic of the instrument cluster circuit. Without the multitude of wires that previously existed, the improvement was unquestionable. There is virtually nothing that cannot be rapidly diagnosed and corrected. All bulb changes can be made quickly and easily. The present design is but a stepping stone toward the completely removable circuit which will carry all of the replaceable elements. The increased use of plastic in the design of components, coupled with their fool proof and permanent location, has eliminated the rattle and noise that is so often associated with the instrument panel even in a brand new car.

Cost Advantages

And finally we come to cost. There is probably no phase of the discussion of circuit conversion that receives so much attention, and quite rightfully. It is not at all axiomatic that the simple replacement of a wiring harness by a printed circuit results in a cost reduction. The cost comparison in the instrument cluster was enhanced by the complication of the wiring harness. The growing number of indicators and warning lights, coupled with the replacement of mechanical gauges by electrical units has increased the number and complexity of circuits required to serve the panel. The rise in the number of ungrounded lighting circuits has also meant more expensive components for use with the normally grounded instrument housing. All this makes for the most favorable condition under which to expect tangible economy from printed circuitry. Since the cost is a direct function of the area that must be covered, aircraft styling with its trend toward instrument concentration has also worked to make the change an economic possibility.

Certainly not all instrument clusters will permit an actual saving. Indirect costs cannot be overlooked; assembly, inspection and handling are subject to reduction. Other less predictable savings, such as the elimination of gauge burnouts due to foolproof assembly, are also reported by the cluster manufacturer. However, even in those cases where only a stand-off is possible, the functional improvement should make the conversion worthwhile.

"Total Design" Approach

Before leaving the all important subject of cost in the instrument cluster analysis, we should consider those additional savings that result from taking a "total design" approach to the problem. We must look not only at the substitution of wiring, but must recognize that the conditions resulting from such a substitution, present the opportunity for general component redesign. In the instruments, for example, we are facing problems of lighting, termination, and attachment, as well as those of circuit design itself. To the specialists in these fields, the possibility of quick automatic assembly becomes apparent. Meter connectors, ground connectors and mounting screws can become quick disconnects and snap fasteners. It is also possible to review conventional items such as lamp sockets. These previously all-metal units are now ideally suited to injection molded thermoplastic.

The ideal approach cost-wise comes when engineers and stylists keep printed circuitry in mind during the earliest planning. This is not always too practical, although wider use and familiarity may cause some natural drift in this direction.

We can also give immediate consideration to a number of small wired components. As an example, consider the indicator light in a transmission control housing where space is a problem. A small rigid unit combining socket, circuit, and mounting would consume less space and improve the assembly. This is representative of the many uses that will turn up.

The Electrical Devices

The second major area for printed circuit potential is in the electrical devices themselves. It is almost impossible to pick up a switch, terminal board, fuse block, connector or for that matter any electro-mechanical unit without contemplating the substitution of a heavy duty printed circuit.

Multi-circuit control switches are a good example for a little closer analysis. These have always been a fertile area for conversion. In fields where the art has been more completely developed, it is common-place to design switches around a printed circuit. Television tuners formerly made up of intricate stamped conductors individually rivited to insulators, are now being made in a much simpler manner, taking advantage of etched circuitry.

There are at least three major reasons why a printed circuit can be advantageously applied to switches. For example:

First: it is possible to make certain very complex types of switches which simply could not be made by any other system.

Second: other less complex devices could be made at lower cost, particularly in short runs.

Third: printed switches can often be included with printed wiring with an attendant saving in cost.

All of these reasons apply in automotive component design. Admittedly in the automotive systems we would have been seriously hampered even a year ago by the relatively light duty circuits then available. They were probably not ready to cope with the man sized requirements of low voltage, direct current switch work. Recent developments in the die stamping field, however, make available conductor thicknesses ten and fifteen thousandths of an inch thick and yet with the full advantage of printed circuitry. The utilization of molded shapes is developing rapidly and will open up even further the potential of this technique in component design.

Door Mechanisms

For the moment dreaming a bit in this category also, let us think about the nightmare that has faced the electrical designer for the past several years as door sections got thinner and the request for power mechanisms in the door got thicker. But is it now possible to mount a plastic panel containing the window lift circuit in the door section and switch these circuits with a mechanism mounted on the inside door panel? Might not printed circuitry lend itself to the simplification of a connector for forward lighting systems? It seems not only possible, but somewhat logical as twin headlights, parking lights and directional signals are tending to concentrate in a single area.

The base materials command the principle attention of the plastics industry. And although the production of

(Please turn to page 63)

Heat Generation and Expansion Effects in the Rheology and Molding of Plastics

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PLASTIC fabrication processes are controlled by the usual laws of fluid mechanics, thermodynamics and heat conduction, and the specific rheological properties of the plastic being fabricated.

Rheological properties must be measured for each plastic and if the measurement is carried out under isothermal conditions the laws of thermodynamics and heat conduction need not be considered since the plastic temperature is known at all points.

If the rheological properties are obtained at a series of different temperatures it is possible in principle (but difficult in practice) to combine these results with the general laws and to predict the flow in more complicated, non-isothermal operations such as in extruders or injection molding machines if the rheological properties are not time dependent; an assumption we will make in this discussion. However, if rheological measurements are made at shear stresses of the same magnitude as those which can be obtained in an injection molding machine, isothermal conditions may be difficult to obtain due to frictional heat generation and expansion. Since this rheological flow problem is closely related to the flow in an injection molding machine, a study of the simpler problem also throws some light on the more complicated one.

In a capillary tube rheometer a molten plastic is forced steadily through a tube as shown in Figure (1). The flow is due to the pressure difference between the two ends of the tube, $P_1 - P_2 = \Delta P$, the pressure drop or pressure loss; but a better measure of the force causing flow is the pressure gradient $\Delta P/\Delta x$, the pressure drop divided by the tube length. Under normal conditions the pressure gradient is related to the shear stress by the equation

$$\tau = (\Delta P/\Delta x)\ \tfrac{1}{2} r = \tau_w\, r/R \qquad (1)$$

so that the shear stress increases from zero at the tube center to its maximum value of τ_w at the wall. The shear stress is the force between two adjacent layers of fluid and the rheological problem is to relate the shear stress at any point to the rate of strain at that point (the rate at which the two layers of fluid slip past each other, given by the velocity gradient, du/dr). Experimentally, one measures the pressure gradient imposed on the capillary and the resulting flow rate, the latter being the integrated effect of all the different rates of shear across the tube. Frequently the data is presented as a mean rate of shear versus the shear stress at the wall, but in order to use this data for computing the flow under other conditions the data must be converted to a relationship between the stress and rate of shear at a point. There are various ways of converting the mean data to point data under isothermal conditions, but when the flow is non-isothermal this conversion is much more difficult.

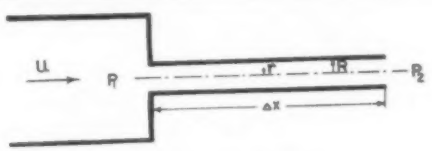


Figure 1. A capillary tube rheometer.

Overall Energy Balance

The fluid which leaves the capillary is at a lower pressure than when it entered and consequently it has lost flow energy. This pressure loss is mainly a result of the viscous friction which is essentially what is measured by the stress-strain relationship. Since the first law of

thermodynamics states that energy can neither be created nor destroyed, this mechanical energy loss must appear as some other form of energy, and most of it will appear as thermal energy (heat). Part of this heat may be lost by conduction to the tube walls and the remainder will appear as a temperature rise of the fluid.

If the fluid expands in flowing through the tube there is a cooling effect due to this expansion and the mean temperature rise is decreased. By means of an overall energy balance, the mean rise in temperature is found to be (1)

$$C_p \Delta T_m = [(1 - T_m\varepsilon)/\rho] (\Delta P/J) - \Delta KE - q \qquad (2)$$

where C_p is the heat capacity, T_m is the mean absolute temperature across the tube, ΔT_m is the mean temperature rise along the tube, ρ is the density, ε is the coefficient of thermal expansion, J is a conversion constant, ΔKE is the change in kinetic energy, and q is the heat loss through the tube wall per unit mass of fluid. This equation is quite general and does not contain any rheological properties or geometrical terms. The kinetic energy term measures the energy change due to changes in the velocity of the fluid—it is usually small. The term $T_m\varepsilon$ is a measure of the effect of fluid expansion. Rather surprisingly it is not negligible for plastics. For polystyrene it is about 0.2 and for polyethylene about 0.3.

For an adiabatic tube where the heat loss is zero and for negligible kinetic energy changes Equation (2) reduces to

$$\Delta T_m = [(1 - T_m\varepsilon)/J] \Delta P/\rho C_p \qquad (3)$$

and it can be seen that for the above polymers the effect of expansion reduces the mean temperature rise by 20 to 30%. For polystyrene the adiabatic temperature rise for a pressure drop of 10,000 lb/(sq. in.) is about 43°F. This rise is independent of the dimensions of the capillary and is relatively independent of the entering polymer temperature.

Since the rheological properties of polymers are temperature sensitive, a temperature rise of this magnitude would cause an appreciable increase in the rate of flow over what it would be if the flow were isothermal. At certain points the temperature rise can be much greater than the mean rise while at other points the fluid may actually cool. The quantitative effect of the mean temperature rise depends upon the dimensions of the apparatus as well as other factors so that rheological measurements made under these conditions would be incapable of describing the flow in another apparatus. If the tube wall is kept at a temperature equal to the iniet fluid temperature, part of the heat generated will be removed by conduction to the wall. To estimate this heat loss (q in Equation (2)) and the effect of the temperature rise on the rate of flow, the problem must be considered in greater detail than above.

Complete Adiabatic Flow

To a close approximation the rate at which heat is generated per unit volume at any point in the fluid is equal to the shear stress times the rate of shear,

$$\phi = (\tau/J)\, du/dr \qquad (4)$$

and the rate at which heat is being consumed by expansion is

$$\phi_e = (T\varepsilon u/J)\, dp/dx \qquad (5)$$

Both of these terms are taken as positive.

The difference between these two terms gives the net heat released in the element and this must be equal to the heat picked up by the fluid in flowing through the volume element plus the heat conducted out of the element. The differential equation obtained by this procedure (2) can in principle be solved with the flow equation to give a complete solution for the temperature and velocity at any point when the rheological properties are known. Thus, it is necessary to assume a rheological relationship (or extrapolate one determined at lower shear rates), solve the equations, and check the results against experimental data.

A good deal of general information can be obtained from the energy equation without a complete solution.

Thus if we neglect conduction in the fluid we obtain

$$u\rho C_p \Delta T = (\tfrac{1}{2} r\, du/dr - T\varepsilon u)\, \Delta P/J \qquad (6)$$

and ΔT gives the temperature rise at any point in the stream. If this equation is averaged across the stream it gives Equation (3) as expected. The term on the right is the net generation term which contains the effects of heat generation and expansion. The heat generation is a minimum in the tube center where the shear stress is zero and a maximum at the wall, while the expansion term is a maximum at the tube center and is zero at the wall. Consequently, the fluid at the tube center tends to cool while the material near the wall tends to heat.

If the rheological properties of the fluid can be described by a power law of the form

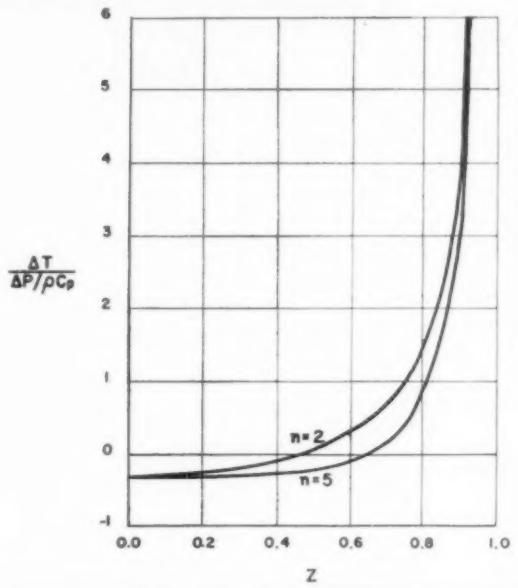
$$du/dr = A\tau^{n-1} \qquad (7)$$

and if we neglect the effect of temperature on the rheological equation, Equation (6) becomes

$$\Delta T = [(\tfrac{1}{2} n Z^n/1 - Z^n) - \varepsilon'] \Delta P/\rho C_p \qquad (8)$$

where ε' is defined as $T\varepsilon$ and Z is r/R. This predicts a linear fall in temperature in the center of the tube where Z = O, and an infinite temperature rise at the wall where Z = 1. This can be seen in Figure (2) where Equation (8) is plotted for various n with $\varepsilon' = .3$.

Figure 2. Theory predicts temperature effect at various distances from stream wall (Z).



Although it is possible to have adiabatic flow as described by the mean energy equation (Equation (3)) it is not possible to have complete adiabatic flow as described by Equation (8). Heat will flow into the center of the tube by conduction from the hot regions near the wall, even if the walls are adiabatic, so that the rise near the wall and the fall in the center will tend to be leveled off. Actually, the fall in the center from Equation (7).

$$\Delta T = -\varepsilon' \Delta P / J \rho C_p \qquad (9)$$

is a good approximation for short tubes or high velocities where the conduction from the wall region does not have time to reach the tube center.

Isothermal Wall

To take into account the conduction it is necessary to specify the conditions at the wall. Solutions of the energy equation are available for the case where the wall is kept at the temperature of the entering fluid, (3, 4) and the rheological properties are independent of temperature, as well as for the adiabatic wall case (3). These solutions are only first approximations but it appears that more accurate calculations which account for the variation of fluid properties with temperature will have to be done on computing machines. An example of this type of calculation is given by Gee and Lyon. (5)

Figure (3) shows in dimensionless form the radial temperature profiles for a material such as polyethylene (4). X is the reduced tube length; $(3X/5R)\ (k/\rho C_p R U_m)$, where k is the thermal conductivity and U_m is the mean velocity; Z is the reduced radius, r/R; and θ is the reduced temperature $(T - T_w)/(R^2 U_m \Delta P/10\, k\, x)$, where T_w is the wall temperature. As the polymer flows down the tube, the center cools by expansion while the material near the wall heats up by friction. Adjacent to the wall the temperature is held at the inlet temperature by conduction to the wall so the maximum temperature occurs a short distance in from the wall.

It can be seen from these curves that the mean temperatures calculated from the overall energy equation only give part of the picture. Near the wall the temperature can be much higher than the mean value and in the center it will be much lower—in this case it will be less than the inlet temperature.

The temperature at the center of the tube falls at first as given by the adiabatic equation, but after some distance this fall is arrested by conduction from the hot surrounding fluid. This is seen more clearly in Figure (4) where the temperature at various radial distances is plotted against tube length. At Z = O, the tube center, the temperature rapidly falls at first and then begins to rise, but even for a very long tube the centerline temperature does not return to the inlet or wall temperature, because the cooling due to expansion is too great to be overcome by the conduction.

Injection Molding

In the injection molding process the work done on the plastic by the plunger is not negligible. Essentially all this work is converted into heat by the end of the process and this heat added by the plunger is of the same magnitude as the heat added by conduction from the cylinder.

For example, if a piston delivers its full pressure during its stroke (after compressing the solid polymer particles) the work done per unit mass of plastic is P/ρ. At 20,000 lb/in² this is roughly 60 BTU/lb, enough

Figure 3. Reduced radial temperatures profiles when wall temperature equals inlet temperature; $\varepsilon' = 0.3$ and $n = 3$.

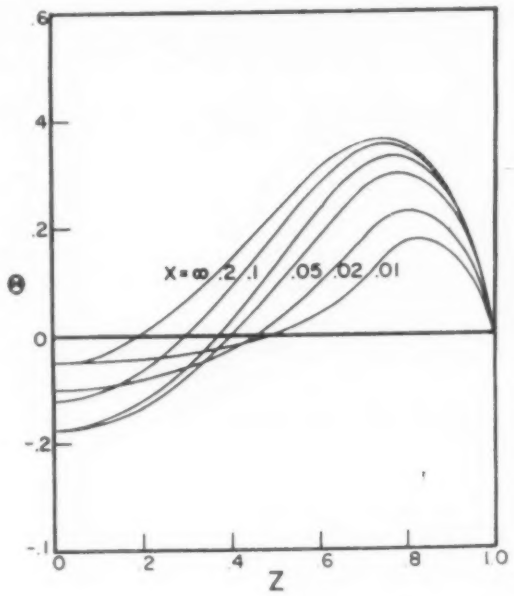
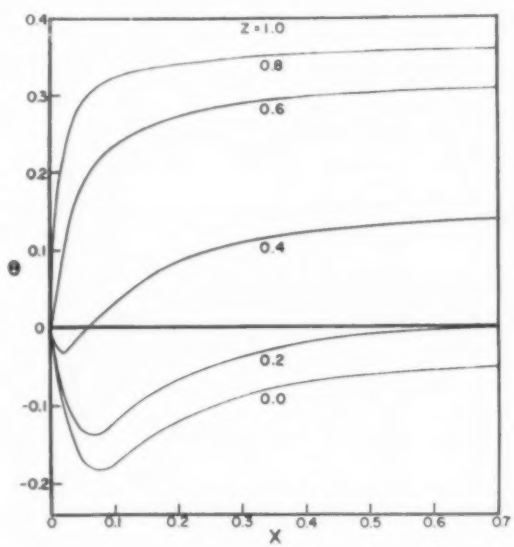


Figure 4. Reduced axial temperatures profiles when wall temperature equals inlet temperature; $\varepsilon' = 0.3$, $n = 3$.



energy to raise the temperature of polystyrene 130°F, and equivalent to 35% of the total energy needed to heat polystyrene from 70°F to a molding temperature of 460°F.

The energy added by the piston is converted into heat by friction during a cycle, but the details of how this conversion takes place are appreciably more complicated than in the rheological problem discussed above.

The two cases are closely related, however, in that both depend upon the same laws of fluid flow and heat transfer

There are two major differences between the rheological problem and the problem of determining the flow in the injection molding process:

1. The former is steady state while the latter is unsteady state i.e., the conditions are independent of time in the rheological study while they vary with time in the molding process.
2. The wall temperature is usually equal to the inlet temperature in the rheological case while it is usually different from this in the molding process.

It is likely that a steady state is never reached in the molding process. The rate of flow varies with time during the process, and even for a steady flow a finite time is necessary for the temperature profiles to develop.

Nevertheless, it has been possible to sketch out broadly the fashion in which the energy delivered by the piston is converted into heat by using the mean energy equation (6) (Equation 2). In this procedure the unsteady nature of the system is accounted for by using time mean pressures and velocities so that the mean temperatures which are calculated are essentially time mean quantities and the heat transfer is neglected or estimated.

This crude method can be refined somewhat by retaining the steady state approximation, but instead of using the mean energy equation, solve the point energy equation for the particular conditions of interest.

For example, some idea of what takes place in flow through a gate may be obtained by considering a steady flow under conditions representative of those taking place during the cycle. This problem differs from the rheological problem only in the fact that the tube wall is colder than the entering fluid, and the same basic equations apply. It has been shown (7) that the solution to this problem is merely a combination of the solution to the rheological problem and the solution to the standard heat transfer problem in which there is no heat generation or expansion. The difference between the temperature of the fluid at any point and the inlet temperature is the algebraic sum of the temperature differences due to heat transfer alone and the temperature difference which would be obtained with heat generation and expansion if the inlet temperature were equal to the wall temperature. The first term has been calculated for a fluid with power law rheological properties (8) and the second has been computed for the case $n = 3$ and for various values of ε'. (3, 4)

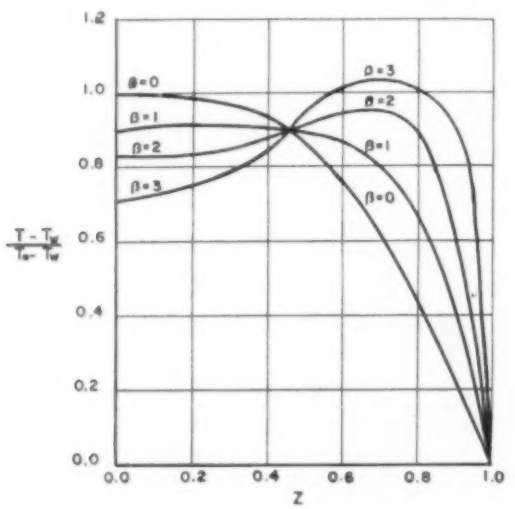


Figure 5. Temperature profiles for various values of β.

Thus, in flow through a cold gate or runner the reduced temperature profiles shown in Figures (3) and (4) have superimposed on them the profiles due to the extra conduction to the cold wall. The profile at a reduced length X due to cooling alone is shown in Figure (5). (Curve $\beta = 0$). How these curves are combined to give the actual profile depends in general upon the group $\beta = (1/x)\ (\Delta T_m/\Delta T_o)$. ΔT_m is the adiabatic temperature rise given by Equation (3) and ΔT_o is the temperature difference between the entering fluid and the wall. When β is small the heat generation and expansion effects are negligible with respect to the cooling and profiles of the type shown in Figure (3) result. When β is large the heat generation and expansion are important. Figure (5) shows typical profiles for various values of β and as β increases the characteristic fall in the center and rise near the walls becomes more apparent.

In the extreme case of very high velocity flow through a short, small diameter gate β is very large. Under these conditions the temperature in the tube center falls due to expansion essentially adiabatically as given by Equation (9) and the effect of the cold wall is felt only in a narrow region near the wall so that the peak temperatures can be very high. The cooling is very small and the mean temperature rises due to the heat generation. This rise is less than the adiabatic rise given by Equation (3), but tends to approach it as the value of β increases. (i.e.q in Equation (2) approaches zero).

The above discussion is based on a number of assumptions, possibly the most serious being that the physical properties are not temperature dependent. Thus, any calculations (except for the adiabatic case) must be considered as approximate. For this reason no attempt has been made to calculate the effect of the temperature changes of the fluid on the flow, even though this is one of the most important questions one would like to answer.

Thus, although a good deal of information can be obtained from the basic equations, the direct application of rheological data to such a complicated process as the injection molding cycle can only be carried in a semi-quantitative fashion. The interaction between the rheology, the heat transfer and the flow is extremely complicated and a great deal of work will be necessary before any reliable quantitative predictions will be possible. ★★

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BLOCK COPOLYMERS

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. . . block copolymers are made up of molecules which consist of alternating groups or "blocks" of different polymers. They are in effect a kind of "multiple graft" copolymer, and as such extend the range of possible "tailor-making" of polymers. Their methods of preparation and properties are discussed in this second of two articles, the first of which, Graft Copolymers, appeared in our last issue . . .

BINARY copolymers of *A* and *B* possessing any one of four isomeric structures have been prepared: an ordered or regular copolymer (I), a random or disordered copolymer (II), a graft copolymer in which branches of poly–*B* are appended to a backbone or trunk of poly–*A* (III), and a block copolymer in which poly–*B* is interspersed along the chain of poly–*A* (IV).

–*ABABABABABABABABABAB*–
I

–*AAABBBBBABBAABABAABA*–
II

$$\begin{array}{cc} & \\ B & B \\ B & B \\ B & B \\ B & B \\ -AAAAAAAAAA- & \end{array}$$
III

–*AAAAAABBBBBAAAABBBBB*–
IV

Graft copolymers (III) have been the subject of a previous presentation *(9)*. The present discussion is concerned with the preparation and properties of block copolymers (IV).

The length of the uninterrupted stretches in IV may vary from one to several hundred monomeric units. Block copolymers may be prepared by alternately growing stretches of different monomers, by rupturing a polymer chain and adding on a new block, and by coupling blocks derived from different monomers.

ADDITION COPOLYMERS

Free Radical Initiation

The synthesis of block copolymers by free radical initiation involves the addition of a second monomer to the end of a growing chain radical, the activation of a polymer containing a labile end group or the rupture of a polymer chain to produce free radicals which add on a new monomer, and the use of poly-functional initiators and chain transfer agents to grow blocks alternately.

Initiation by Growing Chain Radicals

Block copolymers of butyl acrylate–styrene and acrylonitrile-styrene have been prepared in a flow system. Butyl acrylate monomer, containing 1-azo-bis-1-cyanocyclohexane as a photosensitive initiator, was subjected to very intense ultraviolet radiation while streaming rapidly through a capillary. The monomer issuing from the capillary contained a high concentration of free radicals and on entering a large excess of styrene monomer initiated its polymerization. Thus, blocks of polystyrene were added on the poly(butyl acrylate). Similarly, acrylonitrile monomer was irradiated in a capillary and made to flow into styrene monomer to produce polyacrylonitrile containing blocks of polystyrene *(11)*.

The tendency for long-lived radicals to form in the vapor phase polymerization of both methyl methacrylate and chloroprene has been utilized in the preparation of what has been referred to as a multilayer polymer sandwich but which was probably a block copolymer. A layer of poly(methyl methacrylate) was laid down on the walls of a reaction vessel. The system was freed of methyl

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methacrylate vapor and filled with chloroprene. The latter polymerized spontaneously, presumably over the original layer. By repeated alternation of monomers a macromolecular sandwich was formed.

Block copolymers have been prepared *in situ* by using a mixture of a water-soluble and an oil-soluble monomer. Acrylic acid or methacrylic acid was dissolved in water, and styrene was emulsified in the water phase. Using a persulfate catalyst or a hydrogen peroxide–ferrous sulfate mixture, polymerization of the acid occurred in the water phase until the growing chain diffused into a micelle containing styrene monomer, whereby styrene units grew on the polyacrylic acid chains forming a block copolymer.

The trapped radicals remaining on polymer particles when an emulsion polymerization is taken to completion have been used to initiate the growth of a block of polymer derived from an added monomer. Thus, a block of polyacrylonitrile has been grown on polyvinyl chloride, polyvinylidene chloride, and their copolymers by adding monomeric acrylonitrile to a just completed emulsion polymerization of these monomers *(7)*. Similarly, blocks of poly(methyl methacrylate) have been grown on emulsion polymerized polyvinyl acetate *(1)*.

Initiation by Activation

The polymerization of a monomer in the presence of a polymer with a labile end group has resulted in block copolymerization. Styrene was polymerized in the presence of carbon tetrabromide or trichlorobromomethane to yield polystyrene containing a bromine atom at one end and either a tribromo or a trichloro group at the other end. When this polystyrene was dissolved in methyl methacrylate and irradiated with ultraviolet light, cleavage of the carbon-bromine bond resulted in the formation of terminal free radicals which initiated polymerization of the methacrylate to form a block copolymer. The bromine free radical liberated by the scission of the terminal carbon-bromine bond initiated the polymerization of the monomer to yield poly(methyl methacrylate) (V) *(8)*.

Initiation by Rupture of Polymer Chains under Shear

Under the influence of applied shear polymer chains can be ruptured to produce free radicals at the ruptured ends of the chains. Block copolymers have been prepared by utilizing the radicals from chain rupture to initiate the polymerization of a monomer present in the polymer being subjected to the shearing forces. When a mixture of two polymers is subjected to applied shear block copolymers are produced by the coupling of the free radicals at the ends of segments derived from the different polymers. In practice, the products are actually mixtures of block and graft copolymers, since chain transfer in some instances results in the location of the free radical in a non-terminal position on the polymer chain. Further, since styrene is the only monomer whose polymerization has been shown, to date, to terminate by recombination, the termination of two radical-containing fragments should be by disproportionation to yield one polymer chain terminated by a double bond. The copolymerization of the latter with a free radical-containing fragment would yield a graft copolymer.

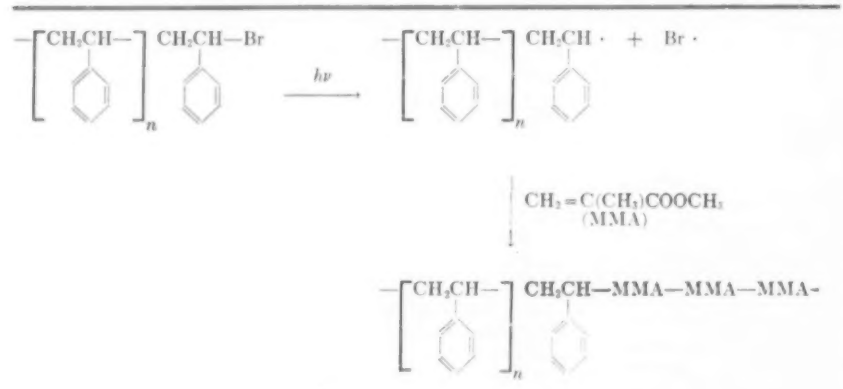
The shearing forces utilized in the polymer degradation to produce free radicals include intensive shaking, high speed stirring, milling, kneading, grinding, pumping through gear and piston pumps, passage through filters and capillaries, and exposure to ultrasonic radiation. Among the polymers which have been subjected to such degradation are addition polymers such as polyvinyl chloride, polybutadiene, polystyrene, polymethacrylic acid, and polyacrylamide, as well as cellulose esters and ethers, linear phenol-formaldehyde condensation products, and linear phthalic acid–glycol polyesters.

Mechanical agitation of the types described above has been used to prepare block copolymers by the degradation of various synthetic and natural high polymers in the presence of monomers. The operability of this method has been shown by the increase in molecular weight when polystyrene, polymethacrylonitrile, and poly(methyl methacrylate) are agitated in this manner in the absence of air, in the presence of their respective monomers.

Numerous block copolymers prepared in this manner from vinyl polymers and monomers are given in Table I. In addition, mechanical treatment of ethyl cellulose in the presence of methyl methacrylate monomer, and of the polyamide hexamethylene trimethyladipamide in the presence of acrylonitrile, has yielded the corresponding block copolymers *(12)*.

Irradiation with ultrasonic waves results in the degradation of polymers and the production of free radicals. Thus, poly(methyl methacrylate), polystyrene, polymethacrylic acid, and polyacrylamide have been shown to yield free radicals under the influence of ultrasonic waves.

The ultrasonic degradation of a polymer in the presence of a monomer has been used in the preparation of block copolymers. Although initial attempts to polymerize methyl methacrylate, styrene, and vinyl acetate in the presence of degrading poly(methyl methacrylate) were inconclusive, block and graft copolymers have been successfully prepared from polyacrylamide-acrylonitrile *(10)* and polymethacrylonitrile-acrylonitrile *(12)*.



V

The simultaneous degradation of two different suitable polymers results in the formation of block copolymers by the cross-termination of the resultant radicals. Ultrasonic degradation of a mixture of polystyrene and poly (methyl methacrylate) has resulted in the preparation of a block copolymer which is probably of a sandwich type since any copolymer formed can undergo further degradation *(1)*.

When natural rubber is cold milled or masticated with various vinyl monomers in the absence of oxygen, in a Banbury mixer or similar masticator, graft and block polymers are formed *(3)*. The polymerization of methyl methacrylate or styrene during the mastication of natural rubber has yielded interpolymers which are soluble up to complete polymerization. Chloroprene, acrylonitrile, acrylic acid, methacrylic acid, methyl and ethyl acrylate, acrylamide, and divinylbenzene have yielded insoluble interpolymers with rubber. Vinyl acetate, which has been unsuccessfully utilized in the attempted preparation of graft copolymers on natural rubber by the chain transfer technique, has been unreactive in the mastication procedure.

The composition of the block copolymer formed by the mastication of rubber in the presence of a mixture of monomers is controlled by the monomer reactivity ratios. The approximately equal reactivity ratios in the methyl methacrylate-styrene system results in the formation of a block copolymer whose composition is approximately that of the initial monomer mixture. The large difference in monomer reactivity ratios in the chloroprene–methyl methacrylate system results in the separate polymerization of the two monomers.

Various synthetic rubbers have been successfully masticated in the presence of vinyl monomers to yield block copolymers. Polychloroprene, poly(butadiene-*co*-styrene), poly(butadiene-*co*-acrylonitrile), polyisobutylene, butyl rubber, and polyurethane rubber have been masticated and utilized to initiate the polymerization of monomers such as methyl methacrylate, styrene, chloroprene, methacrylic acid, and acrylonitrile.

Propeller or paddle type agitation has been used to produce the shearing force in the preparation of homogeneous, substantially linear, block copolymers from monomeric styrene derivatives and a natural or synthetic rubber. Monomers such as styrene and *o*-chlorostyrene, alone or in combination with other polymerizable monomers such as acrylonitrile or methyl isopropenyl ketone, have been copolymerized in this manner with natural rubber, polybutadiene, and copolymers of butadiene-styrene and butadiene-acrylonitrile.

Block and graft copolymers have been prepared by cold milling and masticating mixtures of various elastomers. Natural rubber, poly(butadiene-*co*-styrene), polychloroprene, and poly(butadiene-*co*-acrylonitrile) have been cold milled in pairs to effect block copolymerization *(2)*. Cold milling of polychloroprene under nitrogen produces gel, whereas natural rubber can be milled without gel formation. However, milling of mixtures of polychloroprene and natural rubber has produced gels containing the latter. Polychloroprene-natural rubber mixtures have been cross-linked by magnesium oxide with rubber bound into the vulcanizate, after but not before cold milling.

A Banbury mixer or a rubber mill has been used to produce block copolymers from blends of polystyrene, high styrene-low butadiene resinous copolymers, and high butadiene low-styrene rubbery copolymers. The products are tough materials of excellent impact resistance.

TABLE I. BLOCK COPOLYMERS PREPARED BY MECHANICAL RUPTURE OF POLYMER CHAINS IN PRESENCE OF MONOMERS

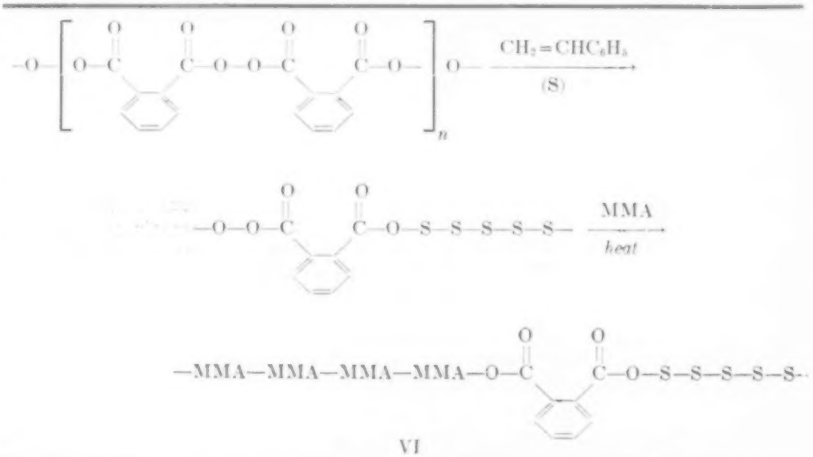
Polymer	*Monomer*
Acrylamide	Acrylonitrile
Isobutylene	Acrylonitrile
	Styrene
	Vinylidene chloride
Methyl acrylate	Vinyl chloride
	Vinylidene chloride
Methacrylonitrile	Acrylonitrile
Methacrylonitrile-*co*-vinyl chloride	Methyl methacrylate
Methyl methacrylate	Methacrylonitrile
	Styrene
	Vinyl chloride
	Vinylidene chloride
	Acrylonitrile-*co*-vinylidene chloride
Methyl methacrylate-*co*-methacrylonitrile	Styrene
Styrene	Methyl methacrylate
	Vinylidene chloride
Vinyl acetate	Vinyl chloride
Vinyl chloride	Methyl vinyl ketone

Polyethylene and butyl rubber have been worked in a Banbury mixer at a temperature above the melting point of the polyethylene to produce a material which forms non-gelling solutions in organic solvents and can be used as a major component of an adhesive for polyethylene surfaces.

Initiation by Polyfunctional Initiators and Chain Transfer Agents

Although the polymerization of a vinyl monomer in the presence of a polyfunctional initiator such as polymeric phthaloyl peroxide, butyl disulfide, and ascaridole has been shown to result in monoradical rather than diradical initiation, polymeric phthaloyl peroxide has been utilized in the preparation of block copolymers.

When the polymerization of styrene with polymeric phthaloyl peroxide was stopped at a comparatively early stage, and the resulting polymer was dissolved in a benzene solution of methyl methacrylate, terminal or internal peroxide groups decomposed into free radicals and initiated the polymerization of the second monomer to form



VI

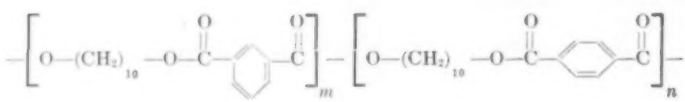
block copolymers (VI) *(13, 16)*. By this method block copolymers containing 20 to 30 per cent styrene have been prepared. Analogously, polyvinyl acetate was prepared with phthaloyl peroxide, and the polymer then heated with styrene to yield a block copolymer containing 40 per cent vinyl acetate. On the other hand, the styrene–phthaloyl peroxide polymer was unable to initiate vinyl acetate or vinyl pyrrolidone polymerization.

Methyl methacrylate polymer has been found to initiate the polymerization of monomeric methyl methacrylate. This has been attributed to the presence of peroxide linkages which have been incorporated into the poly(methyl methacrylate)during its preparation. Methyl methacrylate and oxygen form a copolymer which has a peroxidic structure. When poly(methyl methacrylate) is heated in the presence of its monomer, the peroxide linkages cleave to form free radicals which initiate polymerization. The polymerization of styrene monomer in the presence of poly(methyl methacrylate) results in the formation of what is probably a block copolymer.

The polymerization of styrene using *m*-di(hydroperoxyisopropyl)benzene as an initiator results in the formation of polystyrene containing hydroperoxy end groups. Emulsification of a solution of this polymer in methyl methacrylate with a soap solution, followed by the addition of ferrous ion to decompose the hydroperoxy groups, results in the preparation of a block copolymer *(1)*.

Tertiary amines such as triethylamine are active chain transfer agents, the transfer reaction apparently involving a hydrogen atom attached to an alpha carbon atom. The resultant radical is capable of reacting with a monomer to yield a polymer containing a basic residue. When a polymerization is carried out in the presence of a sufficiently high concentration of tertiary base, each polymer chain carries the terminal base residue. By virtue of this residue the polymer can act as a transfer agent in a second polymerization.

This transfer reaction has been utilized in the preparation of block copolymers. Poly(methyl methacrylate) was prepared in the presence of triethylamine, and the excess base was removed. The polymerization of acrylonitrile was carried out in the presence of this polymer to yield block copolymers containing from 600 to 2000 acrylonitrile units and 200 methyl methacrylate units per chain, joined by a tertiary base residue (VII) *(5)*.



XVII

Carbanion Initiation

Block polymers have recently been prepared involving initiation by electron transfer to monomer *(14, 15)*. The reaction of metallic sodium with an aromatic hydrocarbon such as naphthalene yields a colored, soluble complex which initiates polymerization of conjugated olefins via an electron transfer process:

$$\text{Na}(+\text{ion})\text{napthalene}(-\text{ion}) + \text{styrene} \rightarrow \text{styrene}(-\text{ion}) + \text{naphthalene}$$

The negative monomer ion may be represented as

$$-{:}\text{CHX}-\text{CH}_2^{\cdot} \text{ or } {}^{\cdot}\text{CHX}-\text{CH}_2{:}-$$

At low temperatures the radical ends dimerize to form a species

$$-{:}\text{CHX}-\text{CH}_2-\text{CH}_2\text{CHX}{:}-$$

which does not terminate but consumes all the monomer to produce a "living" polymer, via a carbanion polymerization mechanism.

The addition of styrene to a tetrahydrofuran solution of sodium naphthalene resulted in a change of the green solution to a deep red which persisted even after the polymerization at –80°C. was complete. If an additional amount of styrene was added, the polymerization started again and the reaction again proceeded to completion. If after the completion of the first polymerization step, i.e. the preparation of polystyrene, a second monomer such as isoprene was added, a block polymer was formed of the type *A ... A. B ... B. A ... A*. The addition of a third monomer resulted in the formation of a block copolymer of the type *C.A.B.A.C.* containing another block on each end.

Coupling of Addition Polymers

Addition polymers containing reactive end groups have been prepared by the polymerization of vinyl monomers initiated by specific catalysts.

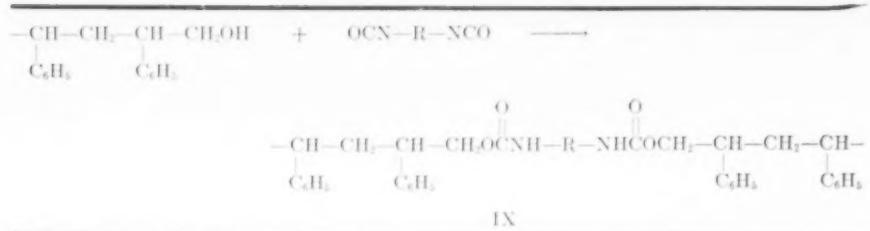
The polymerization of styrene employing 4,4'-azo-(4-cyano-*n*-valeric acid) as initiator has yielded polystyrene containing a carboxyl end group. Since termination in the case of styrene occurs by combination, the polystyrene contained a carboxyl group at each end. The polymerization of methyl methacrylate with this initiator yielded poly(methyl methacrylate) containing a carboxyl group at one end, since termination in this case is by disproportionation. In the case of vinyl acetate and methyl acrylate polymerization the polymers also contained one carboxyl end group. The carboxyl groups in these polymers were converted to the corresponding acid chlorides by treatment with thionyl chloride. Coupling was carried out by reacton with 1,6-hexanediol or 1,10-decanediol *(4)*.

By this method a block copolymer containing two blocks of poly(methyl methacrylate) coupled by the glycol through ester linkages has been prepared (VIII). Similarly, blocks of polyvinyl acetate as well as blocks of poly(methyl acrylate) have been coupled by the glycol. In the case of polystyrene which contained carboxyl groups at both ends the block copolymer contained a number of polystyrene blocks coupled by the glycol.

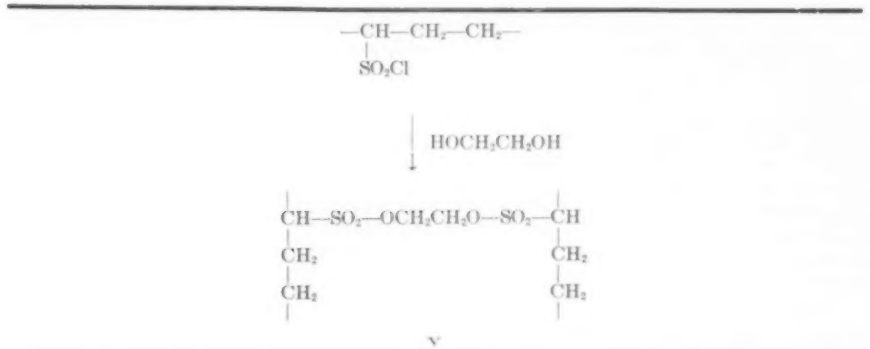
A block copolymer of styrene and methyl methacrylate, in which one block of about 100 units of styrene was located between two blocks of methyl methacrylate each of approximately 120 units, has been prepared in an analogous manner.

The polymerization of styrene in the presence of hydrogen peroxide and ferrous sulfate at a low temperature yields polystyrene containing terminal hydroxyl groups. Similarly, polymerization in solution using a *p*-bromobenzoyl peroxide-ferrous ion-benzoin initiating system gives a polystyrene with terminal hydroxyl groups. Reaction of the hydroxyl-containing polymer with a diisocyanate yields a block copolymer (IX). Diisocyanate coupling reactions are discussed more fully in a later section on condensation polymers.

The reaction of polyethylene with sulfuryl chloride or a mixture of chlorine and sulfur dioxide yields chloro-



IX



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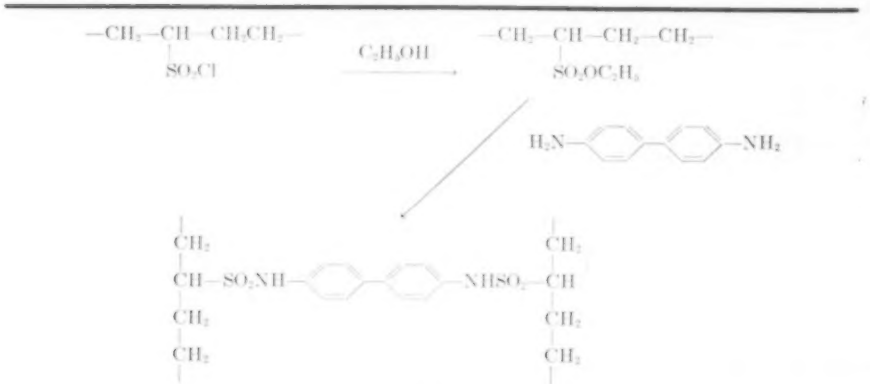
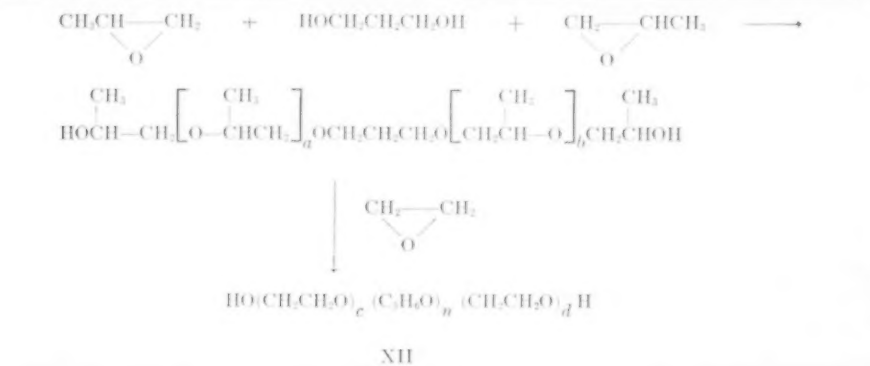
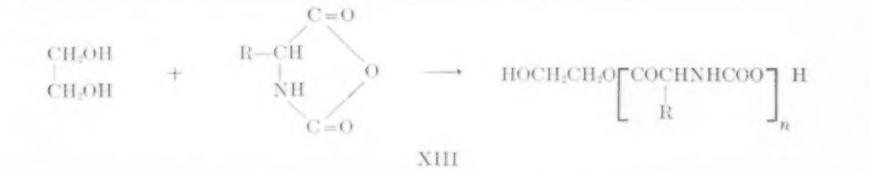


XI



XII



XIII

sulfonated polyethylene which contains—SO_2Cl side-chains. Reaction of the chlorosulfonated polymer with a hydroxyl-containing compound in the presence of an acid acceptor such as an organic or inorganic base gives the corresponding ester. Where the alcohol is polyfunctional, e.g. ethylene glycol or glycerol, a crosslinked block polymer is formed (X). Where the alcohol is monofunctional, the resultant ester can be crosslinked to a block polymer by means of a dioxime such as *p*-quinone dioxime or succinaldehyde dioxime, and compounds containing more than one hydroxyl, mercapto, amino, or amido group such as benzidine (XI).

POLYADDITION COPOLYMERS

The polymerization of a polyaddition monomer such as ethylene oxide which proceeds by successive ring opening reactions under the influence of a reactive group can be utilized to grow blocks on a polymer containing reactive end groups.

The polymerization of propylene oxide initiated with propylene glycol yields macromolecules containing hydroxyl end groups. If the reaction is continued with ethylene oxide, growth occurs at both ends of the center block (XII). The product is a block copolymer with a center block of polypropylene oxide and two end blocks of polyethylene oxide. The "Pluronics" are commercially available non-ionic surface-active agents of this type where the center block contains 20 to 40 propylene oxide units and the end blocks are of various lengths. Since these copolymers contain hydroxyl end groups, polypropylene oxide can again be grown on each end.

Similar linear block copolymers can be obtained by polymerizing an alpha-amino-N-carboxyanhydride (Leuch's anhydride) with a bifunctional initiator (XIII). The poly-

merization of ethylene oxide or another alpha-amino-N-carboxyandydride can then be initiated by the reactive end groups of this polymer to form a block copolymer (XIV).

CONDENSATION COPOLYMERS

Copolymerization and Interchange Reactions

Although initial reports on the attempted preparation of block copolymers by the copolymerization of adipic, sebacic, or terephthalic acid with polyoxyethylene glycols of medium molecular weight indicated that the polymers were waxy products of low melting point, excellent mechanical properties and high melting points have been obtained in block copolymers of polyethylene terephthalate and polyoxyethylene glycols *(6)*.

The copolyesters of polyethylene terephthalate have been prepared by heating dimethyl terephthalate, ethylene glycol, and varying amounts of polyoxyethylene glycols at 275°C. The block copolymers consisted of amorphous polyethylene oxide blocks interspersed among the crystalline polyethylene terephthalate blocks (XV). As much as 30 per cent of the amorphous component did not appreciably lower the melting point while the block copolymer retained the tenacity and extensibility of unmodified polyethylene terephthalate. The dyeability, moisture regain, and flexibility were all materially increased.

Analogous copolyesters of polyethylene terephthalate have been prepared in which the secondary blocks were derived from polyoxydecamethylene glycol as well as the reaction products of 2,2'-bis(*p*-hydroxyphenyl)propane and ethylene oxide (XVI).

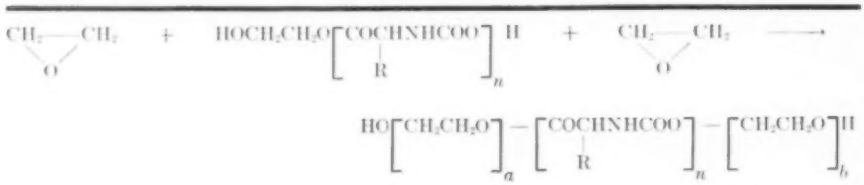
The fact that the products of these reactions are copolymers and not melt blends of polyethylene terephthalate and polyoxyethylene glycol was shown by the incompatible mixture obtained by heating the two components together for eight hours at 275°C.

When a mixture of 6,6 nylon (polyhexamethylene adipamide) and 6,10 nylon (polyhexamethylene sebacamide) was heated under nitrogen at 290°C., amide interchange occurred. During the heating, the interchange reaction resulted in the formation of block copolymers containing blocks of 6,6 nylon linked to blocks of 6,10 nylon. At the end of two hours equilibration resulted in what was either a block copolymer of uniform composition or a true random copolymer.

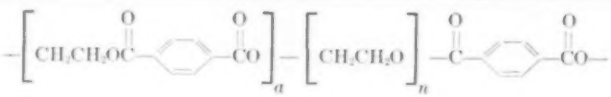
Coupling of Condensation Polymers

Block copolymers have been prepared from condensation polymers by a stepwise procedure wherein the blocks are prepared separately and then coupled through terminal reactive groups. If two polymer blocks contain different terminal groups which are capable of reaction, block copolymers are formed as a result of such reaction. If the two polymer blocks contain the same or similar terminal groups, a bifunctional coupling agent capable of reacting with such groups is used to prepare block copolymers.

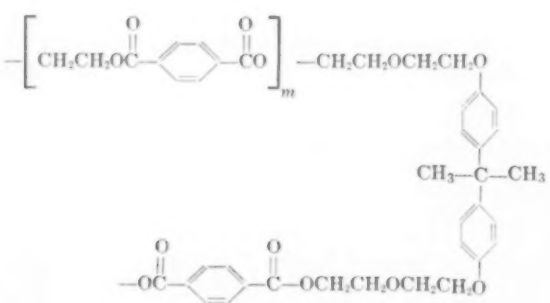
Coupling by Reactive Terminal Groups



XIV



XV



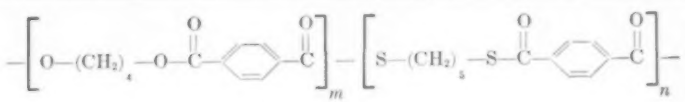
XVI

Polyesters containing reactive terminal groups have been prepared and coupled to yield block copolyesters. Thus, poly (decamethylene isophthalate) with acid chloride end groups was prepared by reacting decamethylene glycol with a slight excess of isophthaloyl chloride and carrying the reaction to substantial completion. Poly-(decamethylene terephthalate) with hydroxyl end groups was prepared by reacting excess decamethylene glycol with terephthaloyl chloride. The reaction of substantially equivalent proportions of the two initial polyesters yielded a block copolymer (XVII). A block copolyester of tetramethylene terephthalate and tetramethylene isophthalate was prepared in an analogous manner.

A block copolyester of tetramethylene terephthalate and pentamethylene dithioterephthalate was prepared by reacting poly (tetramethylene terephthalate) with acid chloride end groups, from tetramethylene glycol and terephthalate) with mercapto end groups, from pentamethylene dimercaptan and terephthaloyl chloride (XVIII).

A polyester having terminal acid chloride groups has been used to couple two polyesters having terminal hydroxyl groups.

A number of commercially important block copolymers are based on the reaction of alkyd resins with polymers containing reactive groups to give useful coating compositions.



XVIII

The so-called alkyd-amine resins are generally crosslinked block copolymers resulting from the interaction of an alkyd resin and a urea- or melamine-formaldehyde resin. The alkyd resin contains hydroxyl and carboxyl groups which react with the methylol or butoxymethyl groups of the amine-formaldehyde resin.

The alkyd-silicone resins result from the reaction of the hydroxyl and carboxyl groups of the alkyd resin with the hydroxyl groups of the silicone resin.

Epoxy resins, prepared by the condensation of epichlorohydrin with a polyhydroxy compound such as 2,2'-bis-(*p*-hydroxyphenyl)propane or glycerol, contain secondary hydroxy groups and terminal epoxy groups which are capable of reacting with functional groups in polymers to form linear or crosslinked block copolymers.

Polyamides containing terminal primary amine groups and internal secondary amine groups are used to cure epoxy resins and give block copolymers ranging from rubbery, resilient solids to hard, tough, shock-resistant masses, depending upon the molecular weight and structure of the polyamide and the ratio of polyamide resin to epoxy resin.

Polysulfide liquid polymers are mercaptan-terminated chains which are capable of reacting with the epoxy groups of the exoxy resins to give block copolymers. Side mercaptan groups occur occasionally along the polysulfide chain and participate in crosslinking reactions. The properties of the products, ranging from brittle to highly flexible compositions, depend upon the ratio of polysulfide polymer to epoxy resin.

Various aldehyde condensation resins are used in conjunction with epoxy resins to give block copolymers which are used in coatings and adhesives. Thus, phenol-formaldehyde, urea-formaldehyde, and melamine-formaldehyde resins contain methylol groups which can react with the hydroxy and epoxy groups of an epoxy resin to give block copolymers which are highly crosslinked and heat-resistant.

Alkyd-amine resins can be blended with an epoxy resin to give a somewhat more complex block copolymer system.

The hydroxyl groups of an epoxy resin can react with fatty acids to form esters which are soluble in hydrocarbons and oils. With unsaturated fatty acids such as dehydrated castor and linseed types or rosin acids, tall oil or dimer acids, the resultant resins have drying characteristics and give cured block copolymers.

The epoxy resin esters based on unsaturated fatty acids can be copolymerized with vinyl monomers such as styrene or acrylic esters to give complex block copolymers containing units based on addition polymerization and others based on condensation polymerization.

Hydroxyl-containing addition polymers such as partially hydrolyzed vinyl chloride–vinyl acetate copolymers can react with an epoxy resin to give block copolymers.

Coupling by Non-polymeric Polyfunctional Coupling Agents

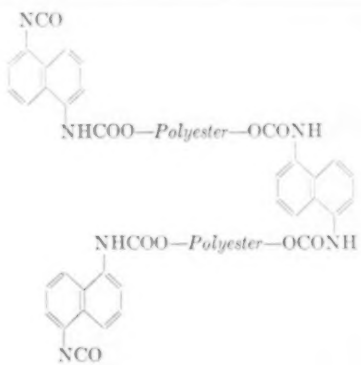
Various non-polymeric bifunctional compounds have been used to couple polymers containing reactive groups.

Poly(decamethylene isophthalate) and poly (decamethylene terephthalate), each having terminal hydroxyl groups, have been coupled by condensation with a diacyl chloride such as terephthaloyl chloride. Two polyesters, each having terminal acid chloride groups, can be coupled by means of a glycol or a dimercaptan.

The reaction of an epoxy resin with a diamine results in ring opening. Since the epoxy resin contains epoxide groups at both ends the product contains blocks of epoxy resin separated by the diamine. Generally polyalkylene polyamines such as triethylene diamine or tetraethylene pentamine are used and result in crosslinking due to reaction of both internal and terminal amino groups.

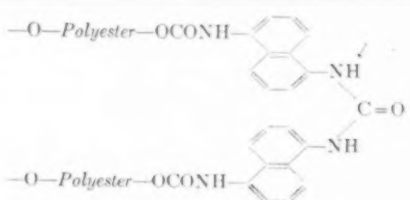
Acid anhydrides of dibasic acids such as phthalic, maleic, and succinic acids react with the hydroxyl groups of an epoxy resin to form crosslinked block copolymers. The half ester formed by the reaction of the anhydride and one hydroxyl group contains a carboxyl group which can react with the terminal epoxy groups of the epoxy resin.

Various polyurethane rubbers, e.g. Vulcollan (Bayer), Chemigum SL (Goodyear), and Adiprene (du



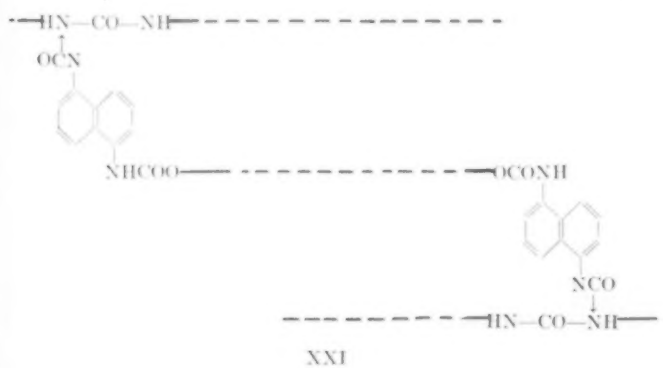
XIX

Pont), have been prepared by the reaction between diisocyanates and polyesters or polyethers containing terminal hydroxyl groups. The reaction is generally carried out with an excess of diisocyanate to yield a polymer



XX

in which the polyester blocks are coupled by urethane linkages and contain terminal isocyanate groups (XIX). The addition of water to the "isocyanate-polyester" results in additional chain lengthening through urea group formation. The urea bridges, however, contain reactive hydrogen atoms which in their turn are in a position to react with isocyanate (XX). With polyesters containing isocyanate groups, reaction with these reactive sites results in crosslinking and network formation (XXI). The essentially linear forms are united at relatively few points by the formation of a network, but this structure imparts the highly elastic properties to the products.



XXI

Glycols and diamines are also used as crosslinking agents in the reaction with the "isocyanate-polyester." In the former case crosslinking occurs through urethane groups while in the latter case urea groups are attacked. Other bifunctional compounds such as amino alcohols and dicarboxylic acids are also useful as crosslinking agents.

Branch-chained polyesters, which contain trifunctional units such as glycerol and trimethylopropane in addition to bifunctional components, can also be used in the preparation of elastomeric compositions.

The reaction of an isocyanate with a carboxylic acid results in the liberation of carbon dioxide. The use of a polyester containing carboxyl as well as hydroxyl groups leads to the formation of a foamed product. The addition of water also liberates carbon dioxide and is used in foam formation.

Diisocyanates have been used to link together two different polyesters having terminal hydroxyl or carboxyl groups so that the two repeating units occur in blocks. When various amounts of polyethylene sebacate and polyethylene adipate are coupled with hexamethylene diisocyanate, copolymers containing up to 40 per cent of the adipate have the same melting point as that of polyethylene sebacate. Further increase in the adipate content results in a rapid drop in melting point until the melting point of polyethylene adipate is reached. In this series no great difference is found in impact strength between random and block copolymers. If, however, the crystalline polyethylene adipate is replaced by the non-crystalline polypropylene adipate, then block copolymers containing 15 to 30 per cent of the latter have outstanding impact strength.

Block copolymers of a polyester and an epoxy resin have been prepared by means of coupling with a diisocyanate.

Crosslinked block copolymers have been prepared by coupling a saturated polyester with an unsaturated polyester by means of a diisocyanate and then copolymerizing the resultant unsaturated addition product with a vinyl monomer. Thus, polyethylene adipate containing terminal hydroxyl groups is reacted with excess hexamethylene diisocyanate to yield a polymer containing terminal isocyanate groups. Reaction of this polymer with bis-diethylene glycol maleate yields an unsaturated block polyester which is copolymerized with styrene in the presence of benzoyl peroxide. The unsaturated block polyester may also be prepared by reacting two moles of the diisocyanate with butenediol followed by reaction with a saturated polyester. The resultant unsaturated polyester can then be copolymerized with a vinyl monomer.

PROJECTION

The interaction of polymeric molecules containing reactive groups has long been utilized in the preparation of new compositions possessing properties different from those of either of the reacting species. This represents only one of the many methods described in this article for the preparation of block copolymers by addition and/or condensation polymerization techniques. These tools have already resulted in the tailor-making of numerous articles of commerce and promise newer products in the future. ★★

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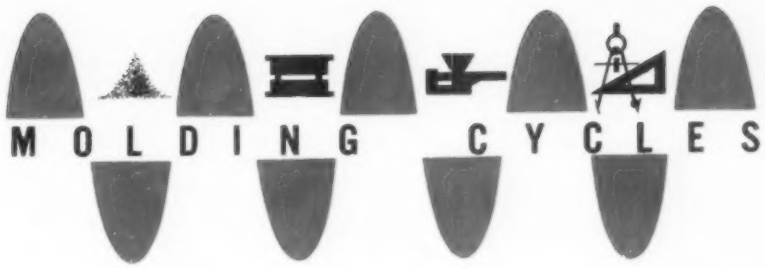


Edited by **Louis Paggi**, *Consultant, E. I. du Pont de Nemours & Co., Inc.*

Restricted Gates for Balanced Flow

Louis Paggi

IT HAS LONG BEEN known that it is very desirable to fill all cavities of a multi-cavity mold at the same time and to the same pressure, and maintain the pressure in all cavities for the same length of time. Failure to accomplish this will result in numerous problems including those of uniformity of dimensions and physical properties, ejection and appearance.

From a practical standpoint, uniform filling of all identical cavities of a mold can be accomplished by employing relatively large runners to feed restricted gates of uniform dimensions. The greater the difference between the diameter of the gate and the runner feeding it, the greater will be the differential pressure developed between the filling of the runner and flowing through the gate. Also the more uniform will be the pressure developed in all of the cavities. The greater the number of gates used to bleed off material from the runner system, the greater must be the cross-sectional area of the runners in order to maintain the desirable back pressure in the runner system to achieve balanced flow. This behaviour is analogous to water flowing through a perforated pipe.

If the perforations in the pipe are of large size and number, they will tend to reduce the back pressure in the pipe. The perforation nearest to the inlet of the water will throw out a longer stream of water than the perforation further removed from the inlet. If the number and size of the perforation cannot be reduced, it will be necessary to increase the diameter of the pipe or the pressure on the water until the flow emerging from all of the perforations is of the same magnitude. (Of course, there are theoretical limits where the pipe is so long and the diameter so narrow that the necessary pressure to achieve balanced flow cannot be reached). The problem here is simply one of reducing the friction due to flow within the pipe to a level which is significant.

In dealing with water and other Newtonian fluids the rate of flow out of all orifices could be maintained uniform by adjusting the diameter of each orifice. This would involve using a smaller orifice near the inlet of the pipe, with the orifice increasing in diameter as its position with respect to the inlet to the pipe becomes more remote. Adjusting orifice diameter to maintain uniform flow is practical with Newtonian fluids but it is not practical with non-Newtonian fluids such as molten plastics for the following reasons:

1. The effect of temperature on the viscosity of the molten plastic makes it possible to calcuate the pressure drop along the runner. This pressure drop, due to shearing of the molten plastic while flowing, can be greatly reduced or increased by small changes in temperature or applied pressure. The losses can be so great as to permit filling a cavity near the sprue through a .030 inch diameter gate while a ¼ inch diameter main runner a few inches long will be incompletely filled. The behaviour may also be erratic as to fill a cavity at some remote location in the mold well before filling a nearby cavity.

2. The difference in time required to solidify a small gate versus a larger gate in the same mold will result in filling similar cavities to different densities and therefore different dimensions.

We may agree, therefore, that the use of restricted gates of uniform dimensions is the most practical for all molds requiring balanced flow in order to produce parts having dimensions and properties as uniform as possible. Occasionally, however, we encounter items which cannot be directly gated with restricted gates. This is generally true of massive parts where the volume per unit time delivered to the cavity must be large or of parts having heavy sections where the use of small gates will cause jetting into the cavity regardless of location of the gate. Restricted gating for these items may be employed by the use of indirect gates such as "tab gates" or by using slit or flash gates. In some cases it may be advisable to employ a combination of both gates where the tab feeds the cavity and the tab in turn is fed by a flash or slit gate. Whatever the choice of gate, the length or "land" of the gate should be as short as possible. The use of long lands will introduce the high pressure drop and erratic behaviour previously discussed.

The many benefits to be derived from indirect gating, properly applied, are well known by the majority of molders. However, indiscriminate use of indirect gates will on occasion result in higher production costs without any improvement in quality.

The following analysis of restricted gates may be useful in determining the best type to use.

Restricted Gates in General:

All restricted gates assist in blending the material entering the cavity. They offer back pressure against the molten plastic in the runner and, therefore, assist in balanced filling.

Direct Restricted Gates of Small Cross-Section:

This gate is best suited for low volume and thin section parts or where the material entering the cavity is immediately deflected back against the flow stream by the opposite wall of the cavity. The cost of degating is low or non-existent. In fact, the shot may not hang together if the gates are very small, the knock-out is poorly balanced or the individual part is too heavy.

Flash Gate:

The flash gate is best suited for balanced filling of large area cavities having thin sections. Because it is thin it provides back pressure and good blending of the melt as well as a fast "freeze-off" between the runner and the cavity. For best results from a standpoint of stress concentration in the molded item it should feed the entire projected edge of the cavity facing it. To avoid jetting it should be very short in length of "land". A good figure for land length is ½ or less of the thickness of the gate. It should be located on a plane with the top or bottom surface of the cavity so that the material entering the cavity will immediately contact one of the cavity surfaces and deflect against the incoming flow of material. The linear flow into the cavity provided by this gate holds the melt shearing in the cavity to a minimum, thus resulting in higher effective cavity pressure. This gate, provided it is very short, may be extremely thin (gates as thin as .010 inch have been successfully used) without a serious loss in efficiency. The combination of

(please turn to page 42)

SPEAKING OF EXTRUSION

Edited by R. D. Sackett
Technical Service Associate
Monsanto Chemical Company
Springfield, Massachusetts

Advantages of Extended Barrel Extruders

L. D. Yokana
Hartig Engine & Machine Co.
Mountainside, New Jersey

It is well recognized that today's modern extruder was developed through a series of logical improvements to the "old Rubber Tubers". Most of the developments have been received without too much discussion or fan fare, although the extended barrel extruder and vented extruder have been subject to considerable discussion.

In order that terminology be thoroughly understood, the screw length is expressed in terms of length (L) over Diameter (D) ratio. "L" being the effective screw length or the length from the rear of the feed hopper to the end of the screw, "D" is the inside dfameter of the barrel. Hence a 2" diameter extruder with a 30" effective screw length would be said to have a 15-1 L/D ratio. It should be noted with respect to this that there are some minor discrepancies within the industry in that some extruder manufacturers, in referring to the length, measure from the front of the feed hopper. In some cases the diameter refers to the diameter of the screw rather than the barrel.

Prior to 1946, few significant advances had been made on the development of longer screws. Screw lengths at that time ranged from 6 to 16/1. The thought then was primarily for the screw to convey and melt the polymer under some pressure, forcing it through a die. This produced satisfactory extrusion, but did not take advantage of the many variables available for high quality extrusion, beside temperature and screw speed.

Being aware of this, Hartig developed the first 21-1 L/D screw in 1946, and briefly thereafter, the 24-1 extruder, and more recently the 30-1 extruder.

Covered below are the major advantages of extra long screws.

1. Extrusion pressures. Far more stable extrusion pressures are attainable by using a 21/1 screw, thereby obtaining better tolerance on the extruded product.

2. Heat can be introduced to the polymer at a much lower temperature gradient, this being of extreme value on materials like vinylidene chloride, polyvinyl chloride and other very heat sensitive materials.

3. Extruder output. Increase in output can be obtained ranging up to 50%.

4. Mixing. Better homogeneity of the resin is possible, which opens tremendous fields beyond extrusion as known today. Extensive laboratory tests on 30-1 extruders have proven this.

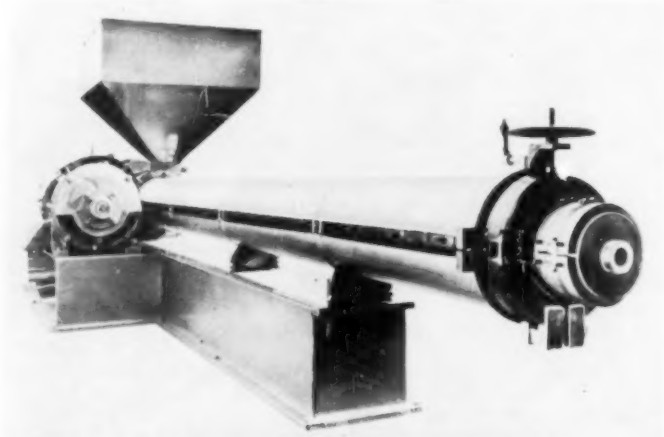
5. Venting or devolatizing. Previously plasticizer, moisture, air or solvent removal had always been referred to in terms ranging from 3% to 5%. Larger quantities were almost impossible to remove. By means of extra long screws, it is possible to talk in terms of 40% now.

In a discussion of this nature it must be realized that there are a great number of variables that affect both extrusion output and quality. Because of this it is not possible to make specific statements concerning extrusion without considerable qualification. Consequently, the precise effect of longer screws will depend to a large extent on the particular set of circumstances under which it is operated. Some of the more important variables are plastic raw material properties, screw geometry and die resistance. The advantages indicated above are typical of the improved operation noted on extended barrel machines in commercial applications. The degree of improved output and/or quality will depend on the interaction of the many variables involved.

It is generally concluded that longer screws are capable of higher presure development and with proper design, this is possible. It should be realized, as recently pointed out by Mr. A. Kennaway of ICI in his talk on "Some Recent Developments in Extrusion" delivered before the 1957 International Plastics Convention, that in some instances the region of highest pressure occurs ahead of the metering section. Under such circumstances, the metering section performs as a resistance and flow regulator and in such instances one would not expect increased output but would anticipate an improvement in quality.

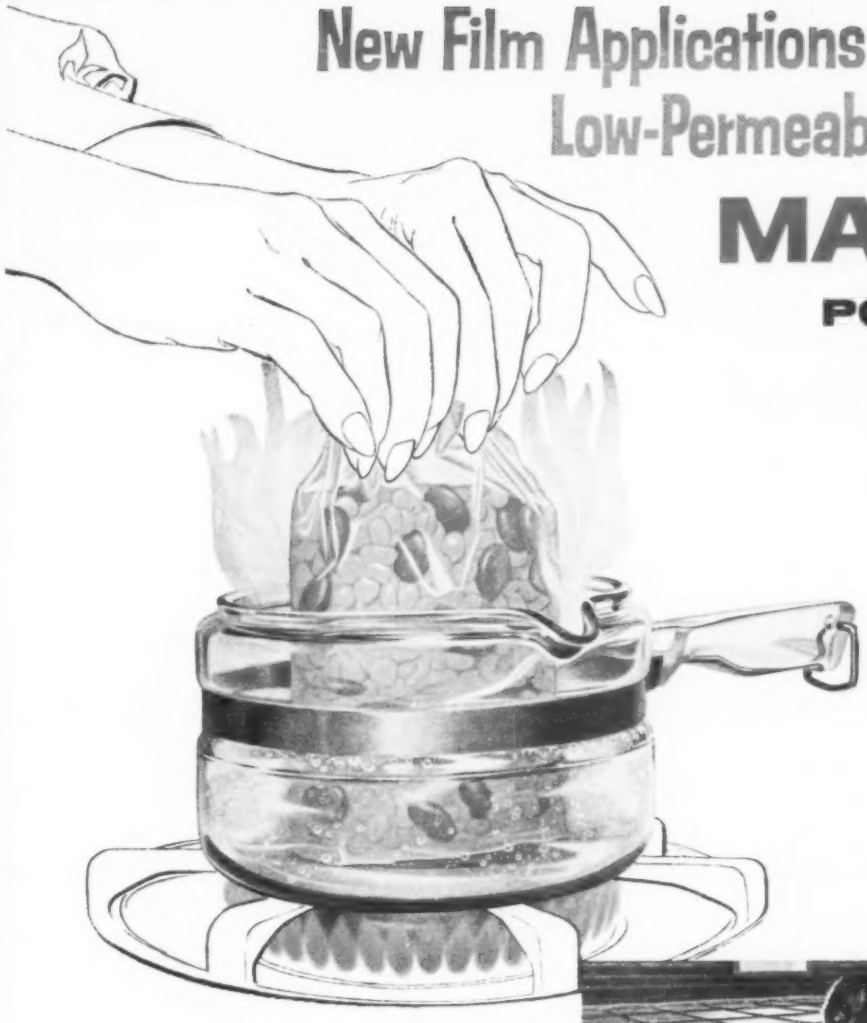
It is in order to mention here that the uncertainty as to where the maximum pressure occurs along the screw length complicates considerably the so called simplified approach to screw design calculations. In the simplified approach it is assumed that maximum pressure occurs at the end of the screw.

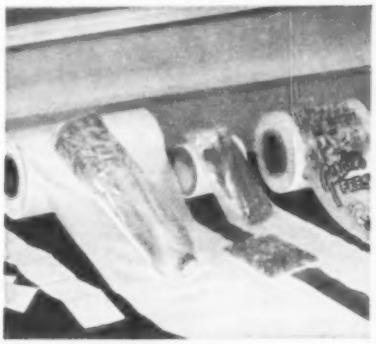
The following are some field observations that have been made indicating the advantages of longer barreled extruders. (turn to page 42)



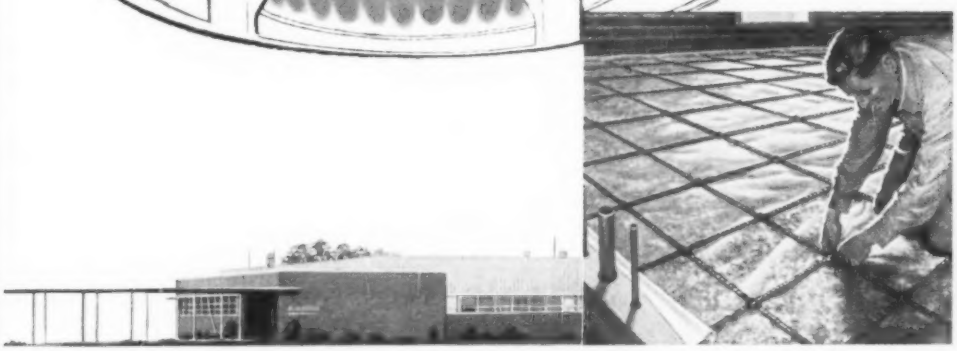
The extended extruder barrel gives greater control and more complete mixing action and removal of volatiles than ever before possible.

New Film Applications with Low-Permeability, Heat-Resistant MARLEX* 50 POLYETHYLENE



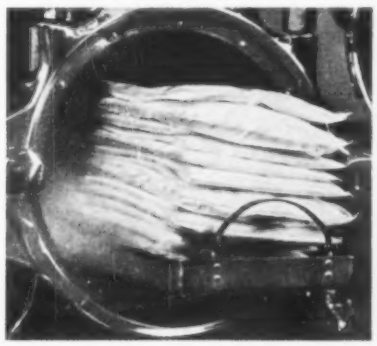


Liquid-tight pouches made from MARLEX 50 film are ideal for packaging foods or industrial products that are oily, wet, frozen or hygroscopic. Foods can be boiled in flavor-sealed MARLEX 50 packages. MARLEX 50 film is impermeable to moisture and most chemicals, and new extrusion techniques yield film with the burst strength and clarity of conventional polyethylene film.



New Sales Service Lab at Bartlesville is completely equipped with latest commercial processing machinery and research apparatus, including environmental test chambers. Phillips experienced technical service staff will assist you in developing new products and processes using MARLEX plastics. Please make arrangements through your local MARLEX sales representative.

High strength and resistance to heat, cold and moisture adapt MARLEX 50 film to many industrial and agricultural services . . . for moisture barriers in building and highway construction, garment bags, drum and carton liners, protective and insulating tapes, high-altitude balloons . . . pond liners, irrigation ditches, mulch, greenhouses, silo caps and liners, protective covers, etc.



Sterilizable MARLEX 50 film is suitable for packaging drugs, medical supplies and instruments . . . covering operating tables . . . and many other hospital uses. Controlled orientation in processing yields a tough, clear, heat-shrinkable film. Excellent stiffness and slip and non-blocking characteristics make MARLEX 50 ideal for use in high-speed packaging applications.

*MARLEX is a trademark for Phillips family of olefin polymers.

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SPEaking . . . (from page 40)

Pressure

This has probably become one of the most important indicating and controlling tools of extrusion. Observed on a 15-1 extruder under fully controlled conditions, pressure variations averaged 9%. In use was a metering type screw with a 4-1 compression ratio.

Under similar test conditions, with a 21-1 screw, the pressure variation was reduced to 3%.

In translating to product tolerance and quality, little explanation is needed. In addition, much higher extrusion pressure can be generated without resorting to special screw or die design. This in turn means better distribution in dies and a general simplification of design.

Heat

Because of longer screws and consequently larger plasticizing capacity, it is possible to introduce heat to the polymer at a much lower temperature gradient. This is of extreme value on unstable materials like vinylidene chloride. Whereas it had been impossible to electrically heat a 15-1 extruder for saran, we now have numerous 21-1 extruders in the field, electrically heated and because of their gentle heat, no degradation.

Where unstable materials do not present a problem the additional plasticizing capacity of the screw can be taken advantage of to increase extruder output. The output increase ranges up to 50%, thereby making the long machine an economically attractive unit to the industry.

Mixing

Where previously it had not been possible to take advantage of variables in screw design because of limited length, the 21-1, 24-1 and 30-1 now offer means for more thorough mixing and compounding. Screws with compression zones, mixing torpedoes, blisters and pressure restrictions are available, where the correct degree of mixing can be given to the resin, with any one or a number of these design features.

With a 30-1 extruder we have been able to compound carbon black into polyethylene; this was never previously possible.

Whereas venting or devolatizing has been limited previously to a moisture removal of 3% to 5%, it is now possible to remove upwards of 40% on special applications. This can again open many avenues for extrusion.

By incorporating three vents on our 30-1 extruder, with equivalent decompression zones on the screws, 40% volatiles were removed.

In conclusion, an effort has been made to point out the many and different special paths that are open to extrusion. It should be kept in mind that when incorporating any of these features in a machine, the extruder ceases to be universal. It is then primarily detailed for a specific application. It can be said that this is particularly true of vented extruders.

Molding Cycles . . .

(continued from page 39)

good melt blending, high cavity pressure and rapid "freeze-off" usually results in cycle economy and better quality in items where it is applicable.

Indirect Restricted or Tab Gates:

When a large cross-section gate is necessary to establish a good flow pattern into the cavity (to minimize surface knit lines or flow marks) and the combined cross-sectional area of all of the gates exceeds the cross-section of the main runner, tab gates may be preferred. If the cavity requires fast filling, tab gates will prove of little benefit.

This type of gate may also be used to control the rate of filling of the mold in the absence of ram speed control in the hydraulic system of the machine. It may also be used when high stress concentration near the area of the gate is likely to prove troublesome. If, because of a high volume requirement, the gate from the runner to the tab will exceed approximately .060 inch diameter, the gate should take the form of a thin elongated slit rather than a full round or rectangular gate. In this way, the back pressure and fast "freeze-off" at the gate will be combined with high volume delivery.

In all cases it is preferred that the tab be fed at right angles to rather than in line with the cavity. Direct or in-line gating of the tab may result in excessive stressing at the entrance to the cavity as well as jetting.

General:

It should be recognized that balanced filling of a mold cannot be realized when the flow of material is restricted by a sprue or nozzle that is too small or when serious restrictions to flow are present in the plastifying cylinder. ★ ★

Rheology Society Meets

The Society of Rheology held its 1957 Annual Meeting in Princeton, New Jersey, on November 7-9. The technical sessions and business meeting were held at Textile Research Institute. The meeting was marked by having the largest attendance in the history of the Society: 122 members and 43 guests.

At the Social Hour Smoker on the evening of November 7th, Dr. Clarence M. Zener, Director of the Research Laboratories of the Westinghouse Electric Corporation, was presented the Bingham Medal of the Society. The presentation of the medal was made by Dr. Arthur S. Nowick, of the IBM Watson Laboratory, Columbia University. Dr. Nowick, a former colleague of Dr. Zener when they were both at the Institute for the Study of Metals at the University of Chicago, discussed the medalist's scientific accomplishments in several areas, including those in regard to the visco-elastic behavior of metals, for which the Bingham Medal was awarded. In his acceptance speech, Dr. Zener stressed the importance of theoretical models in scientific work.

At the Business Meeting, held Friday afternoon, November 8, after the technical session, plans were announced by F. D. Dexter to hold the 1958 Annual Meeting on November 5-7 at the Franklin Institute, in Philadelphia, Pennsylvania. The results of the Society's election of new officers were also announced at the meeting. J. H. Dillon, Textile Research Institute, was elected President, succeeding F. D. Dexter, Bakelite Company. J. H. Elliott, Hercules Powder Company, was elected Vice-President; W. R. Willets, Titanium Pigment Corporation, was elected Secretary-Treasurer; and R. D. Andrews, Dow Chemical Company, was elected Editor. R. S. Marvin, National Bureau of Standards, and R. S. Rivlin, Brown University, were elected Members of the Executive Committee, which also includes the officers and the immediate past President.

New ASTM Group

A new "Four Corners District of A.S.T.M." has been planned for the four states of New Mexico, Arizona, Utah, and Colorado. A very good technical session with outstanding speakers has been arranged for the entire day of January 27, 1958. At the end of the technical session the formation of a district will be discussed. All interested engineers and materials personnel are invited to attend. Some of the papers to be presented are outlined below.

"Accelerated Aging Tests and Life Aging Properties of Aircraft Metal Adhesives" by J. P. Thomas, Convair, General Dynamics Corporation.

"Testing and Exposure Life Test on Metallic Coatings" by C. H. Sample, International Nickel Company.

"Testing for Mold and Fungus Resistance of Material in Storage" by Dr. C. J. Wessel, National Academy of Science, National Research Council.

"Concrete and Its Life Qualities" by W. K. Wagner, Albuquerque Gravel Company.

"Testing and Exposure Life Tests on Paints" by Ralph Wirshing, General Motors Research Labs.

"Materials for the Year 2000" by R. T. Kropf, president of ASTM and vice-president, director of research, Belding Hemingway Co.

For further information, interested individuals may contact: J. L. Abbott, 1902 Richmond N. E. Albuquerque, New Mexico.

F. Perry Wilson is a southerner by birth arriving on the scene December 19th, 1914, in Manson, North Carolina.

In 1936 he graduated from North Carolina State University with a Bachelor of Science degree in Chemical Engineering. In 1941, recognizing the potential of the plastics industry, he joined the Bakelite Company, a Division of Union Carbide and Carbon Corporation. By 1950 he was Sales Manager of Bakelite Company Canada Limited. In 1953 he became Vice-President of the same company and in 1954 he became President. Two years later "Perry" was appointed Vice-President of Union Carbide Canada Limited, and in 1957 he also became President of another Division, Carbide Chemicals Company.

F. Perry Wilson

The Need for More and Better Plastics Engineers

F. Perry Wilson

Here in Canada, as in the United States, there is a serious shortage of engineers in industry. The plastics industry is no exception.

This scarcity of technically trained men is of particular concern to the plastics industry. Plastics is one of the fastest growing fields in the country, having increased twelvefold in the last ten years. Experts predict that the industry will grow as much as 10% again this year. Since the most important ingredient in this rapid expansion is manpower—engineers, salesmen, idea men—this shortage of plastics engineers is very serious indeed.

Once upon a time plastics were considered as substitute materials. This is not true today as people recognize plastics as new and exciting engineering materials. This modern field needs people with imagination.

A good example of how imagination can serve the industry can be taken from house construction. In Canada about three billion dollars will be spent on construction of homes and other buildings in 1957. The proportion of this spent on plastics is negligible. The design of today's buildings results from the limitations of their materials of construction. Rectangular structures were the natural outcome of rectangular building materials. How much more graceful are curved surfaces, easily constructed with plastics! A new outlook is needed in the building industry. Plastics can free man from the limitations imposed by centuries of using conventional materials. Engineers with vision and imagination are needed to adapt the properties of plastics for better construction. The obstacles are great but the goal is rewarding.

Engineers today in the plastics industry have opportunities as never before to progress in research and development, production and sales. Many rewarding experiences await research engineers with the host of new plastics being uncovered, such as polypropylene, high density polyethylene and the various foams. The production engineers are eagerly awaiting an opportunity to produce the new materials. Sales engineers are impatient to get at the selling.

A word here in defense of the much-maligned use of engineers in sales, perhaps more often called technical representatives. It has been said that if all engineers were practising engineering there would be no shortage of engineers. The sales engineers or technical representatives are, if you like, the "shock-troops" of the industry. Technical applications for plastics are more easily understood if explained by technical people. A very significant part of sales is engineering advice. Without it, I assure you, sales are slow. Progressive companies, realizing this, have thoroughly trained their sales engineers in their products and how they are used. Others recognizing the engineer shortage, back up a non-technical sales organization with "trouble-shooter" engineers. No matter which method is used, engineers have their place in sales.

Take for example the polyester-glass structure industry in this country which has lagged seriously behind its counterpart in the United States. Many companies in this line have failed. I contend that if a little more engineering had gone into the products, the market would have been assured and the companies would still be in business today.

I believe no one will question the fact that this progressive industry needs more and better plastics engineers. What can we do about it? How can we who are in the industry be better plastics engineers? I remember some years back, when I was a junior sales engineer "chasing smokestacks" across the country, the burning question always in the back of my mind was: "How could a particular industry use plastic materials to their advantage?" Helping to engineer new applications for plastics is surely the greatest challenge to a salesman. In the past many poorly engineered plastic products have reached the market. The industry is still living this one down. The engineers and the industry should band together to prevent a recurrence. Perhaps the S.P.E. could appoint a committee to instigate a labelling program. The S.P.E. emblem could be moulded into the products, signifying that the product was soundly engineered and approved by the S.P.E. The public would look for and have confidence in the S.P.E. label. In this

(Please turn to page 63)

NEW *for plastic molders...*

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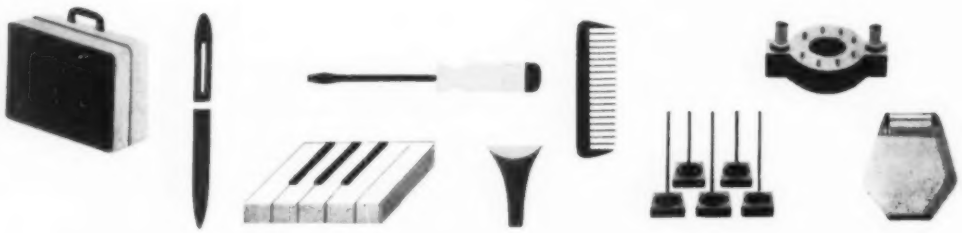

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Action— By Your National Organization

"The objects of the Society shall be to promote in all lawful ways the Arts, Sciences, and Engineering Practices and Standards connected with the utilization of plastics."

The Plastics Institute

During the past year, a group of men appointed by Mr. Jerome L. Formo, recent National President of SPE, has been at work attempting to answer the question, "Is the plastics industry ready to support its own research institute?"

It became evident very early in the study that definition was needed for the term "Plastics Institute". Thus, visits were made to several institutions, discussions were held with many people in the plastics industry, a questionnaire was prepared and circulated and the answers studied and, finally, a model of a proposed Plastics Institute was figuratively built. This "model" is being presented to the Annual Meeting of the SPE National Council this month in Detroit.

"What is the purpose of a Plastics Institute?" This question has been asked from the very onset so it also became necessary to form a tentative answer to it. The Committee used as its guide this threefold purpose:

Research

Education

Dissemination of Information.

As in many others, also in our industry, it is becoming more apparent that we lack much fundamental information about our materials, their processing, and their utilization. We are constantly made aware of the great amount of "art" or "experience" being required and the relatively small proportion of "science" exhibited in the utilization of our plastics. Ours is still more an "art" rather than a "science". There are many reasons for this, but research should help to hasten the day when physical laws can be used satisfactorily to describe the behavior of our materials and processes.

"But what about the research already being done by large corporations in the plastics industry and by the established research institutions?" Yes, a great deal of good research work is being done by these organizations. It would not be a purpose of a Plastics Institute to duplicate such work or to compete with such groups for financial support. Rather, it would be the purpose to complement such activities and to carry out studies which would essentially cut across division lines within the industry. There are numerous basic problems, the answers to which would be of great benefit to material manufacturers, machine manufacturers, fabricators, and even end-users. Often, these basic problems are not attacked because more immediate answers are required to keep profits coming in. Thus, it could be possible for such a Plastics Institute to work at solutions to these problems which can assure the long life and continued success of our plastics industry.

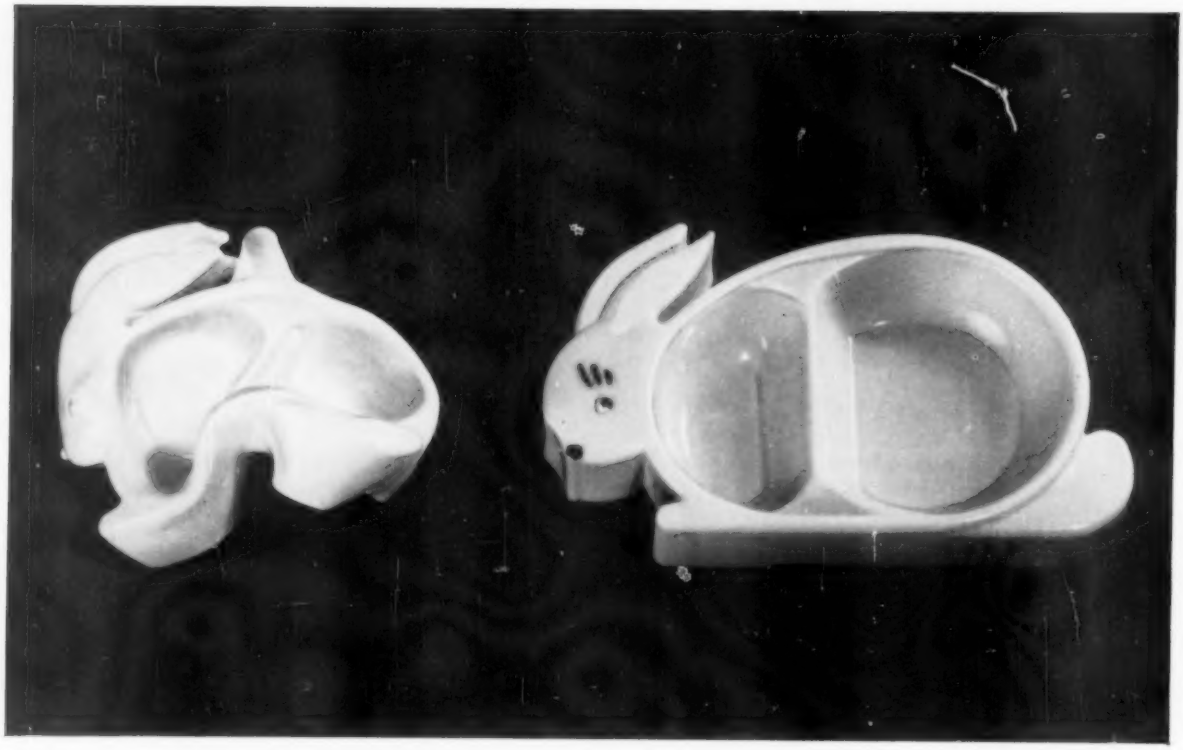
"Yes, I suppose such long range research is necessary, but what about your second purpose, Education? There are many universities in our country. Does the Plastics Institute intend to compete with them?" It is true that there are many universities in this country, but if you have tried to hire a graduate plastics engineer or plastics scientist, you may be aware of the fact that the number of such people is extremely limited and that in most instances, it has been necessary to train your own plastics engineer or pirate them away from your competitors.

At present, however, the "model" of the Plastics Institute is built on the assumption that it should be near or adjacent to a degree granting institution. It is hoped that, while research work on a thesis might be engaged in at the Institute, the course work and also the Master's or the Doctor's Degree would be offered by the college or university. Thus, the education aspect of the Institute would be the result of cooperation rather than competition with our universities.

"Well, that seems reasonable, I suppose. But what do you mean by dissemination of information? Isn't that the function of our established professional and trade

(Please turn to Page 47)

Which one is made of CYMAC®?



When you realize that both these baby dishes have been boiled for thirty minutes...

And that products molded of Cyanamid's new CYMAC Methylstyrene molding compounds won't warp, soften, crack or change color in boiling water...

YOU KNOW the dish on the right is molded of CYMAC! It's one of North Star Industries' popular, easy-priced baby feeding ware and educational toys.

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Write for free booklet, "COLD FACTS on the HOTTEST THING IN THERMOPLASTICS."

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SPE Plastics Institute Committee met December 11 in the offices of F. J. Stokes Corp., Philadelphia, to prepare the model of the proposed plastics institute for presentation to the January, 1958, SPE National Council meeting. Pictured are: seated, left to right, Jerome Formo, chairman, Plastics Institute Committee; Frank McGrew, Arnold M. Varner, and Louis Rahm. Standing, left to right, Buddy Ross, Allan A. Hutchings, H. S. Nathan, SPE vice president; Harry Dubois, Ken Gossett, SPE National secretary; Eugene Quear, Jean O. Reinecke, Jules W. Lindau, SPE national treasurer; and T. A. Bissell, executive secretary.

William O. Bracken and Dr. Gordon Kline, members of the SPE Plastics Institute Committee; Peter W. Simmons, SPE national president, and Frank H. Carman, technical director of the manufacturing Chemists Association, also participated in the discussion.

The Plastics Institute . . .

(Continued from Page 45)

journals?" Certainly, you are right, and the journals are already doing a good job of it. But several things are possible under this purpose. Perhaps it would be desirable to offer plastics library facilities for reference and source work. This could be as limited or as inclusive as necessary to serve those needing it. In addition, a means of communicating research results would be necessary. This could be done through existing channels or through a Plastics Institute Bulletin. In either case, a means must be established to assure that such information is made available to those needing it.

Perhaps from the description of the purpose given above you can surmise that the committee has had a big job to perform. To facilitate the task it was separated into several important groups. These have studied organizations, locations, names, library activities, research policies and projects, personnel, finances, liaison, public relations, and patent policies in order to propose a Plastics Institute which would be patterned on the best features of each of several analogous organizations.

With a clear-cut definition of a Plastics Institute and also a statement of its purpose such as will be presented to the SPE National Council, the next move will be up to the industry itself. If this "model", based on the best examples that can be found, is to become a full fledged reality, it is obvious that the members of our industry must be willing to bring it into being and to continue to support it while it undertakes work that may help to assure the future life of these members.

Jerome Formo

Chairman, The Institute Committee

Professional Activities Meetings

The various PAG groups will meet during the 14th SPE Technical Conference in Detroit. PAG meetings are scheduled on the first two days of the program (Tuesday, January 28 and Wednesday, January 29) at times which will not conflict with attendance at the regular sessions.

All interested persons are invited to attend. For exact time and place of each meeting, check with the SPE Information Desk.

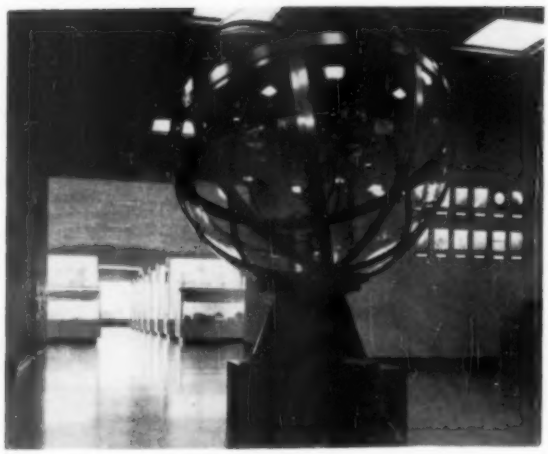
COMMITTEE	DAY	TIME
Plastics in Building	Tuesday	10 a.m.
Compression Molding	Tuesday	Luncheon
Casting	Tuesday	Evening
Forming	Tuesday	Evening
Injection Molding	Tuesday	Evening
Laminating	Tuesday	Evening
Extrusion	Wednesday	Breakfast
Fabricating	Wednesday	Breakfast
Finishing	Wednesday	Breakfast
Metals for Plastics Molds	Wednesday	11:30 a.m.
Plastics in Electrical Insulation	Wednesday	Dinner

"Progress Through Plastics Engineering"

The 14th SPE Technical Conference

Detroit, January 28, 29, 30, 31

The Ambassador Bridge links Detroit with Windsor, Canada.



Left: This model of the solar system stands in the entrance hall of the Institute of Science at Cranbrook.

Lower left: A view of the Detroit expressway interchange in the heart of the city.

Dr. H. D. Pildner

Dr. Harry D. Pildner of the Industrial Division of the Atomic Energy Commission will be the featured speaker at the Yearly Banquet of the 14th Annual Technical Conference of the Society of Plastics Engineers, on Thursday Evening, January 30, 1958 at the Hotel Sheraton Cadillac.

Dr. Pildner's topic will be "Business and Industry in the Atomic Age" and promises to give to the guests, a vast insight into the beneficial utilization of plastics in the future, where the splitting of atoms is a predominate factor in the regulation of every day living. The discourses will delve into the interesting behind-the-scenes activities of the personages who have been responsible for the effective growth in our Atomic Energy Program.

Dr. Pildner is well qualified to discuss his chosen subject as he holds degrees from the Colorado Institute of Technology, Linsdale University and Mt. Holyoke Polytechnic Institute, where he was on the Board of Regents prior to his present appointment.

Dr. Pildner is married, has three children and his hobbies consist of chess, mathematics and astrology.

Special Events

Business Luncheon—12:15 Tuesday, January 28.
"Welcome by city and state officials."

General Luncheon—12:15 Wednesday, January 29
"The Future of Plastics in the Automotive Industry" Charles A Chayne, vice-president, General Motors Corp.

Cocktail Party and President's Reception
6:30 p.m. Thursday, January 30.

Banquet—7:30 p.m. Thursday, January 30
Dr. Henry Pildner, Industrial Division, A.E.C.
"Business and Industry in the Atomic Age"

PROGRAM

The Fourteenth Annual Technical Conference of the Society of Plastics Engineers

Tuesday, January 28, 9:30 — 11:30

Radiation and Plastics - I

Radioisotopes and Plastics by Dr. Paul C. Aebersold, U. S. Atomic Energy Commission

The Role of Atomic Radiation in Plastics Science and Technology by Dr. R. F. Boyer and Robt. McFedries, The Dow Chemical Co.

Accomplishments in Plastic Applications with Radiation — United States and Abroad by J. R. Stirrat, Dr. A. A. Miller, and E. Lawton, General Electric Co.

Tuesday, January 28, 8:00-9:30 p.m.

Education

Theme: Sponsored Research in Plastics

Tuesday, January 28 — 2:00-4:30

Extrusion - I

Beta Gauge Measurement and Control of Plastic Thickness and Area Weight by G. I. Doering, Industrial Nucleonics Corp.

The Effect of Relative Channel Depth and Curvature on Screw-Extruder Pumping Capacity by Dr. P. H. Squires, E. I. du Pont de Nemours & Co.

Power and Heat Energy Relations in Polyethylene Extrusion by B. H. Maddock, Bakelite Co.

Extrusion Theory by L. F. Street, Welding Engineers, and Dr. Hugh M. Hulburt and Dr. Stanley Katz, American Cyanamid Co.

Radiation and Plastics - II

Ionizing Radiation by A. John Gale, High Voltage Engineering Corp.

Operation of a Radiation Facility by J. W. Ranftl, X-Ray Department, General Electric Co.

The Irradiation of a Molded Article by Dr. R. G. Bauman, The B. F. Goodrich Co.

Graft Copolymerization on Polyethylene by H. G. Hammon, Battelle Memorial Institute

Injection Molding - I

Large Section Injection Molding by M. Silovich, Evart Products Co.

Conical Heat Chamber by R. T. Wheeler, Crown Cork & Seal Co.

Preplastification for Injection Molding by E. Gaspar and M. G. Munns, The Projectile & Engineering Co., England

Forming of Aerosol Containers of 'Zytel' Nylon Resins by J. B. Patton and R. M. Bonner, E. I. du Pont de Nemours & Co.

Epoxy Resins and Embedment

Characteristics of Flexible Epoxy Resins by Dr. W. J. Belanger and H. C. Klassen, Jones-Dabney Division, Devoe & Reynolds Co.

Strain Gauge Evaluation of Casting Resins by R. N. Sampson and J. P. Lesnick, Westinghouse Electric Corp.

Material Handling of Epoxy and Polyester Resins by W. A. Gammel, Sr., R-B-M Division, Essex Wire Corp.

Heat Resistant Epoxy Resin Systems by J. E. Carey and F. C. Hopper, Shell Chemical Corp.

Wednesday, January 29 — 9:00-11:30

Packaging

High Density Polyethylene Film for the Packaging Industry by L. F. Swec, W. R. Grace & Co.

Health Safety of Plastics Used in Food Packaging and Housewares by D. D. McCollister and W. J. Sauber, The Dow Chemical Co.

End Use Correlation of Styrene Container Testing by B. Nathanson, Monsanto Chemical Co.

Oriented Polystyrene Film and Sheeting by F. C. Dulmage, The Dow Chemical Co.

Mold Design - I

Machining Practices in Mold Making by E. J. Krabacher and P. A. Ropp, Cincinnati Milling & Machine Co.

Reducing Mold Costs and Improving Quality Through Planning Methods, by Wm. D. Evans, Estee Mold & Die, Inc.

The Theory and Study of Proper Mold Design for High Density Polyethylene by A. Spaak, W. R. Grace & Co.

Mold Polishing by A. W. Logozzo, The Nutmeg Chrome Corp.

Plastic Tooling

Plastics as Used for Tooling Aids in the Stamping Industry by E. Ruddiman, Ford Motor Co.

Aircraft Tooling with Plastics by R. H. Voss, Warren Plastics & Engineering, Inc.

Plastic Application in the Foundry by W. R. Weaver, Modern Pattern & Plastics, Inc.

Plastics in the Metal Working Industry by G. M. Rice, Ren Plastics, Inc.

New Materials - I

Practical Methods of Fabricating Articles from High Density Polyethylene Sheet by D. E. Rottner, Farbwerke Hoechst, Germany.

Molding Characteristics of Diallyl Phthalate Compounds by L. B. Keller, W. R. McGlone, and D. H. Woodin, Hughes Aircraft Co.

Lexan Polycarbonate Resin — A New High Strength, Heat Resistant Plastic by W. F. Christopher, General Electric Co.

Application of Larson-Miller Correlation to Service Test Data on High Density Polyethylene by W. E. Gloor, Hercules Powder Co.

Wednesday, January 29 — 2:00-4:30

Extrusion - II

Effect of Extrusion Conditions on Strength and Appearance of Polyethylene Pipe by J. F. Morris, Spencer Chemical Co.

Rigid Polyethylene Pipe by L. B. Croley and Robert Doyle, Phillips Chemical Co.

Polyethylene Monofilaments by J. F. Groel and J. H. Versteeg, Bakelite Co.

Sheet Extrusion and Vacuum Thermo Forming of Higher Density Polyethylenes by J. G. Farrow, Koppers Co. Inc.

Injection Molding - II

Effect of Processing Conditions Upon Specific Gravity of High Density Polyethylene by J. P. Fogerty and E. Poindexter, W. R. Grace & Co.

New Techniques in Molding Linear Polyethylene by D. A. Jones, Celanese Corp. of America

Better Operation with Better Plant Layout by D. E. Semeyn and R. L. Beesley, The Dow Chemical Co.

Molded Shrinkage and Dimensional Stability of Nylon 6 J. M. Verdi and R. F. Flaherty, Barrett Division, Allied Chemical & Dye Corp.

Test Methods

Measuring Gas Transmission Performance of Plastic Packaging Materials by W. E. Brown and W. J. Sauber, The Dow Chemical Co.

Friction and Abrasion Characteristics of Plastic Materials by M. A. Marcucci, Minneapolis-Honeywell Regulator Co.

Application of the Tensile Impact Test on Plastic Films by R. H. Carey and M. S. Nutkis, Bakelite Development Laboratories

Evaluating Plastics for Compression Molding Phonograph Records by Use of a Capillary Extrusion Rheometer by W. E. Coleman, Monsanto Chemical Co.

Reinforced Plastics

Effects of Elevated Temperature and Erosion of Reinforced Plastic Laminates by N. B. Miller and E. L. Strauss, The Martin Co.

Development of Steam Resistant Fiberglass Reinforced Plastics by Professor E. G. Bobalek, Case Institute of Technology; Wm. Ellslager, The Glidden Co., and T. Harris, Structural Fibers, Inc.

Fabrication of Articles from Acrylic Sirup by J. A. Ross, Dr. Brian Mead Jr., and Dr. J. T. Rundquist, E. I. du Pont de Nemours & Co.

A Discussion of Polyester Premix by W. O. Erickson, Barrett Division, Allied Chemical & Dye Corp.

Wednesday, January 29 — 12:15

Luncheon—Charles A. Chayne—"The Future of Plastics in the Automotive Industry"

Thursday, January 30 — 9:00-11:30

New Materials - II

Polyvinyl Chloride Pearls: Properties and Applications of a Unique Series of Resins by Dr. R. S. Holdsworth, Dr. W. Mayo Smith and J. T. Barr, Escambia Chemical Corp.

European Progress in Plastics by Zoltan Merszei, Dow Chemical International Limited

Properties and Applications of the New Low Viscosity, Solventless, Thermosetting Silicone Resins by M. E. Nelson, Dow Corning Corp.

'Delrin' Acetal Resin — A New Thermoplastic. Properties, Fabrication and End-Use Testing by Dr. J. F. Cogell, Jr., and R. H. Hardesty, E. I. du Pont de Nemours & Co.

Automotive Applications

General Review of Automotive Applications for Plastics by Dr. E. J. Storfer, Chrysler Corp.

Reinforced Plastics in the Automobile by J. G. Coffin, Chevrolet — St. Louis

Polyurethane Foam in the Automotive Industry by M. J. Sanger, The General Tire & Rubber Co.

Plastics in Automotive Trim by R. McCullough, Ford Motor Co.

Mold Design - II

Mold Cost as Affected by New Metal Casting Methods by J. A. Kavanagh, Standard Tool Co.

Practical Design for Hot Runner Molds by J. R. Grenier, Protective Closures Co., Inc.

The Use of Heat Resistant Epoxy Formulation for Producing Low Cost Molds for the Plastics Industry by R. T. O'Conner, Devcon Corp.

Tooling Cavities for Quality Class Commercial II Spur and Helical Plastic Molded Gears by J. R. Venne, Industrial Business Machines Corp.

Color and Finishing

A New Breaker Plate for the Coloring of Polyethylene by J. E. Simpson, Ferro Corp.

Recent Developments on Finishes and Application Techniques for Vacuum Metallizing Plastics by M. A. Self, Logo, Inc.

Hot Leaf Stamping by M. A. Olsen, Olsen Mark Corp.

Dry Coloring Methods for Injection Molding of Polyethylene by J. N. Scott, C. J. Silas, and J. V. Smith, Phillips Chemical Co.

Thursday, January 30 — 2:00-4:30

Extrusion - III

Extrusion of Polyethylene Film with Controlled Properties by W. A. Haine and H. B. Robinson, Jr., Bakelite Co.

Polyvinyl Chloride Dry Blend Extrusion in the Wire Coating Field by E. H. Hankey and R. D. Sackett, Monsanto Chemical Co.

Nylon 6 Tubing — Extrusion Techniques and Effects of Environmental and Processing Conditions on Strength by J. L. O'Toole, H. G. Tinger, and T. R. von Toerne, Barrett Division, Allied Chemical & Dye Corp.

Teflon 100X Perfluorocarbon Resin — A New, Melt-Extrudable Fluorocarbon Resin by R. S. Mallouk and W. B. Thompson, Jr., E. I. du Pont de Nemours & Co.

Potpourri

Publicity is NOT 'Free' by L. R. Greif, Greif-Associates, Inc.

Printed Wiring Processing by E. B. Murphy, Lincoln Laboratory, Massachusetts Institute of Technology

Methods for Joining Plastic Parts by A. J. Cheney and W. E. Ebeling, E. I. du Pont de Nemours & Co.

Plastics Research and Development: Fact or Fancy from a Manager's Viewpoint by R. M. Houghton, Conap Co.

Foams

New Developments in Vinylfoam by H. E. Allen, Elastomer Chemical Corp., Unit of Union Carbide Corp.

Properties of Urethane Foam by Dr. J. H. Saunders, Mobay Chemical Co.

Room Temperature Setting, Heat Resistant, Low Density, Silicone Foams by D. E. Weyer, Dow Corning Corp.

Epoxy Resin Foams by Dr. M. H. Nickerson, DeBell & Richardson, Inc.

Injection Molding - III

Maintenance Program for the Molding Industry by J. C. Engman, Milwaukee Plastics, Inc.

Wiring Diagrams — Their Purpose and How to Understand Them by F. R. Cinco, Reed-Prentice Corp.

Automatic Injection Molding, by O. M. White, F. J. Stokes Corp.

Injection Molding by Automatic Means at Kodak Park Works by L. A. Ulmschneider, Eastman Kodak Co.

Thursday, January 30 — 7:30

Banquet—Dr. H. Pildner—"Business and Industry in the Atomic Age".

Friday, January 31 — 9:00-11:30

New Materials - III

Embrittlement of Polyethylenes by C. S. Imig, Spencer Chemical Co.

Environmental Stress-Cracking of Polyethylene Injection Moldings — Practical Control and Test Methods by R. J. Anderson and S. R. Melvin, Monsanto Chemical Co.

Some Tensile Properties of Fractionated High Density Polyethylene by Dr. L. H. Tung, The Dow Chemical Co.

Early Detection of Weathering Damage in Polyethylene by Dr. J. W. Tamblyn, Dr. G. C. Newland, and M. T. Watson, Tennessee Eastman Co.

Sheet Forming

Technical Aspects of Postformable Decorative Laminates by A. V. Dupuis, Monsanto Chemical Co.

Theoretical Aspects of Vacuum Forming Thermoplastic Materials by P. A. Sauter, Hydro-Chemie, Ltd. Switzerland

Extrusion and Thermoforming of Polyethylene Sheet by E. E. Griesser, A. L. Griff, and H. F. Tomfohrde, III, Bakelite Co.

Advancements in Continuous Vacuum Forming Processes by M. J. Kalahar, Kal Plastics, Inc.

Compression Molding

Compression and Transfer Molding of Epoxy Compounds by W. J. Dewar, Furane Plastics, Inc.

Automatic Preforming of High Impact Phenolic Materials by M. E. Lawrence, Logan Hydraulics, Inc.

Properties Required for Automatic Compression Molding of Thermosetting Materials by F. J. Donohue, Monsanto Chemical Co.

The Development and Application of Automatic Preheating of Thermosetting Powders by D. C. Amsler, Pass & Seymour, Inc.

Rheology

Historical Introduction to the Rheology of Plastics by Dr. E. T. Severs, Natvar Corp.

Criteria for Mixing and the Mixing Process by Dr. J. T. Bergen, Armstrong Cork Company, and G. W. Carrier and J. A. Krumhans of Brown University

Intensive Mixing by Wm. R. Bolen and R. E. Colwell, Monsanto Chemical Co.

Rheological Considerations in Plastics Product Design by Bryce Maxwell, Princeton University

Stand-By Paper

Creep in Polyethylenes at Elevated Temperatures by R. R. Dixon, Westinghouse Electric Corp.

Luncheon Speaker Charles A. Chayne, vice-president General Motors Corp.

CHARLES A. CHAYNE

The engineering background of Mr. Charles A. Chayne with General Motors includes seven years as vice president in charge of Engineering Staff—plus 14 earlier years as chief engineer of Buick Motor Division.

A native of Harrisburg, Pa., Mr. Chayne was graduated in 1919 from Massachusetts Institute of Technology and Harvard University with a bachelor of science in mechanical engineering.

Following graduation he joined the National Advisory Committee for Aeronautics as a junior mechanical engineer. After a year at the Washington NACA laboratory, Mr. Chayne returned to MIT to become instructor in mechanical engineering.

He remained at MIT until 1926 and then became experimental engineer at the Lycoming Manufacturing Company, Williamsport, Pa. A year later he was a power plant designer for the Marmon Automobile Company, Indianapolis, Ind.

He joined Buick in early 1930 and was placed in charge of the engine division. By 1933 Mr. Chayne was assistant chief engineer and three years later took over as chief engineer. In 1951 he was named General Motors vice president in charge of Engineering Staff.

A resident of Bloomfield Township, Mr. Chayne makes antique automobiles his hobby.

He is a member of Pi Tau Sigma, honorary mechanical engineering fraternity, and last June the Gamma Chapter (University of Michigan) named him to Tau Beta Pi, honorary engineering fraternity. Also, last June he was elected to the board of Massachusetts Institute of Technology.

Mr. Chayne's other memberships include Society of Automotive Engineers, American Society of Mechanical Engineers, Automobile Manufacturers Association, the Industrial Committee of the University of Michigan Engineering Laboratories, the British Institute of Mechanical Engineers, Engineering Society of Detroit and American Ordnance Association.

In keeping with his hobby, Mr. Chayne is a member of the Horseless Carriage Club, Sports Car Club of America, Antique Automobile Club and the Veteran Car Club of America and Great Britain.

Save Time and Eliminate Inconvenience

REGISTER IN ADVANCE

Write to The Society of Plastics Engineers, 34 E. Putnam Ave., Greenwich, Conn.

NEWS of the industry

Time Pay Plan

Lester-Phoenix, Incorporated, announces the preparation of a brochure which describes the aspects of three extended payment plans for the purchase of Lester equipment.

For additional information, write: Lester-Phoenix, Inc. 2711 Church Ave., Dept. N-55, Cleveland 13, Ohio.

Sterling Expands

Sterling, Inc., manufacturers of Sterlco temperature control equipment for the plastics industry, has announced completion of a new $200,000 plant and office building in suburban Milwaukee. The new building is situated on a four acre site at 5200 West Clinton Avenue, Milwaukee 18, Wisconsin. The one story brick and concrete block structure has 21,000 square feet of floor space, a vast expansion over the firm's former plant at 3738 North Holton Street, in Milwaukee.

New Potentiometer

A truly distinctive strip chart potentiometer recorder is being introduced by West Instrument Corporation. Entirely free of vacuum tubes, it operates instantly—without warm-up—and functions far longer without maintenance. First in their Model "M" Series, this "Marksman" recorder uses printed circuits and transistors in its amplifier.

Several of the features included in this basic thermocouple recorder by West without extra charge are usually available only at premium prices. Automatic standardization, thermocouple break protection, cold junction compensation, chart tear-off strip, adjustable chart speeds without changing gears, battery condition indicator.

The "Marksman" is now available from regular production. For details, order Bulletin M from West Instrument Corporation, 4363 W. Montrose Avenue, Chicago.

Swedlow Growth

After several years of producing decorative laminates for a few selected customers, Swedlow Plastics Company of Los Angeles, California, and Youngstown, Ohio, announces its entry into the market on a national basis. Swedlow is well known as a producer of transparent plastic glazing parts for military and commercial aircraft, reinforced acrylic and polyester laminate fabrication, honeycomb core and plastic sheets for industrial specifications. For further information write Swedlow Plastics Company, 394 N. Meridian Road, Youngstown, Ohio.

Men in the News

Arnold M. Varner

Arnold M. Varner, formerly of the General Electric Company, has accepted the position of plant superintendent with Capac Industries of Minneapolis.

As plant superintendent, Mr. Varner will be responsible for manufacturing and the laboratories, and will work with J. R. Davidson, vice-president and general sales manager, in product development.

A graduate of M.I.T., Mr. Varner helped organize the Kentuckiana section of the SPE and succeeded Mr. Davidson as national director from that section. He is now a member of the Plastics Institute Committee, chairman of the SPE ASTM liaison committee, and chairman of an ad hoc committee on student membership in SPE.

Jules Pinsky

Jules Pinsky, chief physicist of Plax Corporation, Hartford, Conn., has been named to a subcommittee of the Advisory Board on Quartermaster Research and Development.

Pinsky will serve on the subcommittee on subsistence packaging of the Committee on Containers. The subcommittee is charged with reviewing and evaluating research and development projects in the subsistence packaging area. The group operates under the National Academy of Sciences—National Research Council. Pinsky's appointment is for three years.

Gordon E. Chase

Manco Products, Inc., Melvindale, Mich., has named Gordon E. Chase district sales manager covering Ohio, Indiana, New York, and western Pennsylvania.

The appointment was announced by M. A. Nichols, president of the company, which precision -casts 'Accu - Cast' steel, 'Tru-Cast' beryllium copper, and Manco Bronze mold and die components widely used in molding plastics and other materials, zinc and aluminum die-casting, and related applications.

Mr. Chase is maintaining district headquarters at 477 Stockbridge Ave., Buffalo, N. Y.

T. Walter Noble

Mr. T. Walter Noble, technical director of Decar Plastic Corporation, has been named as chairman of the Decorative Laminate Advisory Technical Committee of the National Electrical Manufacturers Association. For over four years Mr. Noble has been active in the NEMA organization, having served as chairman of the Hardboard Decorative Laminate Subcommittee which is composed of producers of hardboard and fiberboard as well as representatives of the decorative plastic manufacturers. He has also served on other committees of NEMA, working to set minimum standards of performance of high pressure plastic laminates.

The function of this Decorative Laminate Advisory Technical Committee covers the entire group of decorative laminates including; physical properties, test methods, test equipment, and minimum standards of performance under the test methods so established. Furniture manufacturers using decorative high pressure plastic laminates meeting NEMA standards are assured of uniform performance, through the efforts made by the Decorative Laminate Advisory Technical Committee of NEMA.

Thomas Zawadzki

Thomas Zawadzki was elected Vice President in Charge of Sales, and a member of the Board of Directors of Cary Chemicals Inc., Milltown, N.J., on September 25th, the same day it opened its new million dollar PVC Resin plant at Flemington, N.J.

John R. Russell

John R. Russell, formerly research chemist for Firestone Tire & Rubber Company, has recently joined Steere Enterprises, Inc., of Akron, Ohio, as manager of research and development.

Jack Arnold

Jack Arnold, Jr., has been named manager of the Boston office of the Enjay Company, Inc., petrochemicals marketing firm. In his new post he will be responsible for Enjay's sales and other activities in the New England area. The appointment is effective immediately. Enjay's Boston office is at 135 Clarendon Street.

Ray Stratman

Victory Manufacturing Corp., Chicago thermoplastics molder, has named Ray Stratman sales manager of the Housewares Division and Arthur E. Backus sales manager for Industrial and Custom Molding.

William Holland

William D. Holland has been appointed assistant general manager, Commercial Development Division, American Cyanamid Company, it has been announced by W. G. Malcolm, president.

AROUND THE WORLD

UNITED STATES

A.S.T.M. BULLETIN

September, 1957

Abstracter: Walter A. Gammel, Sr.

The Vicat Softening Point Test for Plastics—*C. E. Stephanson and A. H. Wilbourn*

The authors describe an indentation test carried out under conditions of uniformly rising temperature. The test has been adopted by the British Standards Institution.

The present test differs from the Vicat-needle test in using a 1 kg. load rather than 5 kg., and in having a liquid as the heat transfer medium instead of air. Although the test as normally carried out is suitable only for thermoplastics, results appear to be highly reproducible. In a round-robin test involving six laboratories, the Vicat softening point (VSP) differed more than 1°C only once in twenty times. The standard deviation was 0.54°C. From additional data presented it appears that a small error in measuring the indentation has an insignificant effect on the value of the VSP.

Relationships Between Electrical and Mechanical Properties of Epoxy Resins—*John Delmonte*

Curing agents and curing schedules affect the electrical and mechanical properties of epoxy resins. Considering three curing agents, an aromatic amine, a polyamine diethylene triamine, and an anhydride, in stoichometric amounts, volume resistivity is highest in the anhydride cured system, and lowest in the triamine. It was found that Hexural strength tells quite rapidly for unfilled resins beyond the ASTM heat distortion temperature.

Resilient epoxys as prepared were subjected to enlongation measurements and weight loss tests. The fall-off in elongation suggests age embrittlement taking place although initial heating improved properties. Tests results on volume resistivity as a function of per cent hardener indicated a good correlation between peak volume resistivity and stoichiometric proportions for cured epoxy resins.

MATERIALS IN DESIGN ENGINEERING

October, 1957

Abstracter: L. S. Buchoff

Alkyd Moldings for Electrical Uses—*J. T. Long*

Alkyds are used in molding parts for electrical applications because of their excellent dielectric properties over a relatively broad temperature range and excellent dimensional stability. Three types of alkyd molding compounds are available. The granular type provides superior dielectric properties and heat resistance. The putty types are used for difficult mold loading problems and around delicate inserts. The glass-reinforced types are used where high strength and superior dimensional stability are necessary. A chart comparing the seven types of molded alkyds is presented.

Water Thinned Paints for Metal Products

Water thinned paints have been widely used for protecting masonry and interior surfaces because of their ease of application, low odor, nonflammability, and lack of hazard. The article describes a new styrene-butadine latex for protecting metal surfaces. By means of heat and catalysis the butadiene groups in the polymer react to form a thermosetting coating with excellent adhesion, toughness and hardness, and resistance to water, mineral spirits and some chemicals. The new latex is compared with other clear organic coatings in a table of properties. Information on formulation of paints is given.

MECHANICAL ENGINEERING

August, 1957

Abstracter: Philip G. Fleming

Teflon Based Piston Rings for Non-Lubricated Applications—*Richard D. Taber, Fred A. Robbins*

An investigation covering currently available materials, said to have the ability to operate without lubrication, is described. Various tests were conducted at room temperature and at 400°F. in order to simulate conditions found in gas and chemical-process compressors. The results of wear-resistance, chemical inertness, strength and moisture resistance are given in table form.

One of the materials evaluated was designated as K-30, a Teflon-base compound containing fine glass fibers. The authors conclude that the Teflon-base compound has self-lubricating (and other) properties which will permit operation in many applications, without lubrication.

The article is well written and is recommended for reference materials.

ARGENTINA

PLASTICS

September, 1957

Abstracter: John B. Ballard

First Polyvinyl Chloride Plant — *Editorial*

The first Argentine polyvinyl chloride plant will be built in Capitan Bermudez, Province of Santa Fe, by ELECTROCLOR, S. A. I. C. It will have an annual capacity of 4000 tons. The principal investors in this project are CELULOSA ARGENTINA, S.A. and INDUSTRIAS QUIMICAS ARGENTINAS "DUPERIAL", S.A.I.C. Design and technical supervision will be by Imperial Chemical Industries, Ltd., of England.

FRANCE

INDUSTRIE DES PLASTIQUES MODERNES

September, 1957

Abstracter: Hans Mayer

Answer to a Publicity Problem

The problem of a suitable answer to the question of demonstrating and publicising a new product on the road has been answered by the design and construction of a special trailer. This vehicle is built from glass reinforced polyester materials and has folding members which permit its travelling at standard trailer size while it can be expanded to twice its travelling width by unfolding, thus providing sufficient space for demonstrations and guests.

Requirements for Plastic Floor Coatings

With the use of protecting plastic coatings becoming more common certain specifications for the material to be used must be set up. Amongst these are drying time and non toxic condition of the material as far as

the question of application is concerned. As far as minimum conditions for the resulting coating are concerned, resistance to temperature variations, inertia to chemicals, resistance to shock, firm adherence to the coated surface and finally removability without hurting the protected base material are of prime importance.

★

GERMANY

KUNSTSTOFFE
October, 1957
Abstracter: Anne Schwend

This issue is dedicated to the application of plastics in the field of building. Further contributions are scheduled for the next editions.

Floor Covering—*E. Fortun*

Different kinds of plastics flooring, fleximer flooring and floor tiles are discussed as well as the importance of adequate and dry foundation floors. Satisfactory laying methods and maintenance the same as standardization work accomplished so far in this field are ventilated.

Use of Foamed Polystyrene in Surface Building—*B. Ikert*

The properties of foamed polystyrene "Styropor" as supplied by Badische Anilin—and Sodafabriken, are listed and fields of application for sound absorbing purposes, insulation, finishes, etc. briefly discussed.

Glass Fibre Reinforced Polyester Sheets and Corrugated Sheets—*C. V. Brunswick*

Light transmission, mechanical properties, shapes of sheets marketed and bonding of this material the use of which spread quickly during the past five years in Germany, are considered.

Plastic Pipelines for Drinking Water—*A. Mueller and W. Schwartz*

PVC and polyethylene pipelines were submitted to rigorous specifically devised laboratory tests extending over long periods (partly dating back to 1940). Results were compared with those obtained from water works with installed plastic pipelines. The increase in bacilli content observed during the first days after installation or upon stagnation of water within the pipelines, but disappearing later on, was no exception to observations already known from pipes of other materials such as copper. It may be expected that plastic pipelines of satisfactory quality will have the same lifetime as those of customary materials. However, great care and cleanliness should be exercised during production and particular attention should be paid to packaging and joints long-term exposure to certain bacteria or dyes used in the plastics industry.

Plastic Films in the Building Industry—*H. E. Krueger*

Interior decoration with and outdoor use of plastic sheeting under extreme weather conditions are briefed the same as progress achieved in producing satisfactory films for sundry fields.

Plastic Binders, Laminated Wood and Wood-Waste Panels in the Building Industry—*Leopold Skark*

Methods of fabrication of plywood, wood fibre boards largely manufactured by exploiting the bonding substances inherent to wood and panels from resin-impregnated wood chips are reviewed under the aspect of making use in the building industry.

Plastics Insulated or Sheathed Cables for the Installation in Buildings—*H. J. Hilgendorff*

Different kinds of plastics covered and insulated cables for use underground, in the open air and in dry or moist rooms are screened. Soft PVC has supplanted other materials for cable insulation during the past 10 years and has proven its superiority.

Silicones for the Protection of Buildings—*E. Pirson*

Nature and form of application of silicones to inpregnate exterior surfaces of buildings are discussed.

In situ—Insulation with Plastic Foams—*H. Baumann*

Insulation examples from new and old buildings, to protect pipelines, to deaden the transmission of sound, to fill out shafts in concrete buildings and to reduce the inflammability of thatch-covered roofs, etc. are cited. Bactericide properties of urea foams have recently been confirmed.

Plastics and Concrete—*H. W. Schulz*

A survey on the application of concrete or cement mixed with acequeous emulsions of polyvinyl-acetate especially for the repair of damaged concrete structures, sealing of surfaces, as connecting link between concrete and other materials.

Waterproofing with Oppanol BA Foil—*W. Daniel*

The technique of making buildings, tunnels, roofs, etc. water-proof and impervious to weather or ground water in places where building otherwise would be nearly impossible, with the help of polyisobutylene foils under the trade-mark "Oppanol BA" (by Badische Aniline-und Soda-Fabrik) is reviewed.

Plastics for Lacquers and Paints—*H. Disselhoff*

This release from the lacquer laboratory of the Badische Aniline-und Soda-Fabriken deals with the use of plastics for lacquers, paints and varnishes (alkyde resins, non-saponifiable binders for corrosion resisting lacquers, reactive resins for multicomponent lacquers, and plastic dispersions for binding paints and other materials).

Use and Maintenance of Plastic Decorative Sheets—*H. Cuno*

The method of cutting, bonding, jointing, bending and cleaning of plastic laminated sheets for the decoration of furniture and walls are explained.

Plastic Profiles for the Building Industry—*A. R. Boehm*

Examples of new profiles for the building industry such as fillers for expansion joints, sound deadening pipe joints, dowels, wall base decorative profiles and window and door seals are discussed.

Plastics Coated Iron Wires—*K. Hahne*

Coatings of soft PVC and in some extreme cases of polyamide and polyethylene for iron and steel wires have given the architect a new material in and in the neighborhood of industrial plants to prevent corrosion wherever wiring is required.

★

PLASTE UND KAUTSCHUK
April, 1957
Abstracter: Walter Brenner

A Thermochemical Study of the Reaction Between Phenol & Formaldehyde—*Mg. Oldrich Vlk*

This paper discusses previous work on the activation energy of the reaction between phenol and formaldehyde including the author's own studies. The activation energy varies with the phenol-formaldehyde mole ratio, the temperature, pH, and the type and amount of catalyst. The largest activation energies were obtained at the mole ratio of phenol/formaldehyde 1:1.5 with acid catalysts. Base catalysts show lower activation energies. Data are summarized in Table 1 and Table 2 below Table 1: Activation energy of the reaction between phenol and formaldehyde; HCl catalyst; 76-86°C.

P/F mole ratio 1:0.8 1.1.25 1:1.5 1:2. Activation energy Kcal 20 20.0 23.7 23.5.

Table 2: Activation energy of the reaction between phenol and formaldehyde, NH_3 catalyst; 80-86°C.

P/F mole ratio 1:0.8 1:1.25 1:1.5 1:2. Activation energy Kcal 16.9 17.5 18.5 18.2.

These data were obtained from a study of reaction rates according the Arrhenius equation at various temperatures.

The reaction between phenol and formaldehyde is exothermic. The heat of the reaction consists of the addition reaction (Q_a) heat of phenol + formaldehyde + the condensation reaction (Q_k) heats. The total reaction heat is in the order of 23.5 Kcal with a P/F mole ratio of 1:2 with acid catalysts. Experimental studies with a P/F mole ratio of 1:1 gave 19.7 Kcal in an acid medium and 18.8 Kcal in an alkaline medium and confirmed Jones' previous work.

The maximum reaction heats per unit of time are obtained at P/F ratios of 1.8.85. In the first 5 minutes of a P/F ratio of 1:0.84 the reaction speed is double that obtained at a P/F ratio of 1:1.5. This confirms that novolacs are much faster and move more exothermically formed than resols.

GREAT BRITAIN

BRITISH PLASTICS

October, 1957

Abstracter: Evert A. Mol

A Survey of Some Curing Methods of Polyester Resins—*J. W. Cywinski*

The mechanisms of catalyzation and acceleration in the curing of unsaturated polyesters are discussed. The most popular accelerator for ketone peroxide is cobalt naphthenate; however, the author believes that cobalt octoate is much superior. It does not contain any foreign materials, has better color, and its solution in a plasticizer is stable. The organic peroxides used as catalysts each have their own temperature range where they are active as catalysts. This so-called critical temperature varies between room temperature and about 200°C. Of interest to the polyester manufacturer are those with criticai temperatures between 60° and 130°C. Of the ketone peroxides the most commonly used are methyl ethyl ketone peroxide and cyclohexanone peroxide.

Many combinations of catalysts and accelerators are possible to give low temperature, medium temperature, or high temperature curing. For instance, for medium temperature curing, that is, between 35° and 90°C., most of the peroxides require accelerators, with the exception of lauroyl peroxide which can be used at 60°C. Most ketone peroxides have critical temperatures between 70° and 90°C., but they still need accelerators to have any speed below 100°C. High temperature curing takes place above 90°C. The best peroxides that give a long pot-life at room temperature but good operation at high temperatures are benzoyl peroxide, methyl isobutyl ketone peroxide, tertiary butyl perbenzoate, tertiary butyl peracetate, and dibenzyl diperoxide. Particularly the last one is suitable for curing at 140°C. and over. Both benzoyl peroxide and tertiary butyl perbenzoate give very long pot-life, but the activity of benzoyl peroxide at 110°C. is better. The shelf-life of methyl isobutyl ketone peroxide is rather short.

High Speed Screw Extruders—*Erich Beck*

This is a discussion of the principles behind the new, high speed screw-type extruders built by Alpine A. G., Augsburg, Germany. The approach is interesting in that it is a little bit more practical and is still based on theoretical considerations. The author gets away with this practical approach by introducing a couple of new terms, like "output factor of a given thermoplastic material" and "the thermal efficency of the extruder," which obviously is the ratio between the energy intake by the screw and the energy taken out by the extrudate in the form of increased heat content. The introduction of the efficiency term, of course, is in realization of the fact that no extrusion is truly adiabatic. The conclusions and their reduction to practice are very interesting.

It has been shown that a material like polyethylene can be, and is, extruded at screw speeds of 1000 RPM and more; of course, the screw speed in RPM's will be lower for larger diameter screws, the quoted figure refers to a screw of only 5/8" diameter. The Alpine extruders have been fitted with an adjustable back pressure device so that in each case the best conditions for adiabatic operations can be established. Not all thermoplastics show the same suitability for adiabatic extrusion. Materials like polyvinylchloride, of zero or low plasticizer content, may have to be operated too close to the decomposition temperatures.

The author only gave one example of an extruder of a size more or less common in the United States. This was a machine with a screw of 65 mm., or 2-1/2." This machine was operated at 250 RPM and produced close to 130 lbs. of polyethylene per hour, making polyethylene pipe of 88 mm. x 3 mm. The production was fully adiabatic, and the obtained output checked closely with the calculated output of 132 lbs./hr.

Melamine Extends its Range

The melamines are a rather expensive class of material and so their application is naturally limited to more expensive and better products. Even so, the amount of melamines used has been rising steadily so that in 1956 over 28,000 tons of solid and liquid resins were used, together with 20,000 tons of molding compounds.

An important field of application is decorative laminated sheet production that used 1,000 tons over and above the amounts already mentioned. Other large outlets for melamine resin are table ware, electric moldings, wet strength paper, and textiles (Everglaze type). Copolymerization of melamines with epoxies results in better alkali resistance, useful in the metal coating field.

September, 1957

Accelerated Fatigue Testing of Polymethyl Methacrylate—*J. M. Zarek*

This article is mainly a discussion of the results obtained with so-called progressive load methods. In comparison with orthodox methods of fatigue testing, the progressive load method consists of carrying out a number of tests in which the load increases to a value which causes fracture. The rate of load increase is constant in each test but decreases for each successive test. The results are plotted as a curve of the number of cycles to fracture against the stress at the moment of fracture. The type of fracture is affected by the test conditions as high stress combined with low number of reversals and low stress combined with high number of reversals. The tests were run at various frequencies, i.e., 95, 475, 950, 1700, and 2250 RPM. As the bending frequencies increase, the maximum bending stress at failure goes down. The sensitivity of polymethyl methacrylate to the rate of loading is very high, as can be expected from the poor heat conductivity of the material and the high mechanical hysteresis loss.

New 3½ and 4½ Inch Single Screw Extruders—*Anonymous*

The new extruders built by R. H. Windsor Ltd. in England have two interesting features. The first is the use of a hydraulic, variable drive with controlled torque. This drive incorporates an electric motor driving a piston pump with instantly variable delivery that is manually controlled; thus, the pressure of oil delivered to the hydraulic motor can be set from 0 to a maximum of 900 lb./sq. in.

The second feature is in the heating system which uses induction coils delivering a total capacity of 24 KW divided over four heat zones. The cases to the induction coils are also used as air manifolds to permit the introduction of cool air between coils and barrel when necessary.

The extruders under discussion are combined with a complete sheet plant for the production of high impact polystyrene sheet, embodying as the three main units a sheet die, a take-off, and a conveyor-guillotine assembly.

Foamed-in-Place Techniques with Sebalkyd and Flexalkyd Resins—*A. C. Cornwell, D. B. V. Parker, L. N. Phillips*

For some reason, the chemistry department of the Royal Aircraft Establishment has developed a couple of formulations to make rigid and flexible foams. The formulation for rigid foams is called Sebalkyd and is based on a sebacic/succinic/glycerol alkyd; the flexible foam is called Flexalkyd and is based on sebacic/adipic/glycol alkyd. Although it is stated that the chemistry of those resins has been fully reported on, the reports themselves have not been published so that very little has been gained by the statement.

The article contains a large number of very useful tips on foaming techniques. It is interesting to note that the authors consider diisocyanate foam production still more an art than a science. Discussed, among other things, are the effect of cellulose acetate butyrate as a bubble modifier, the action of accelerators like sodium lactate, the correct placement of the flow control plugs to control the foaming pattern, the use of parting agents like Abril PDS wax, the promotion of skin adhesion by using primers, and ways to obtain colored foams.

SWEDEN

SWEDISH PLASTICS ASSOCIATION TECHNICAL BULLETIN
April, 1957

Abstracter: Walter Werber

Lacquers for Plastics—*W. C. Meeuwis, Eng. N. V. Hercules Powder Co, Haag Holland*

The coating of plastics for the purpose of achieving special effects and improved appearance presents all sort of difficulties. Softening or etching of the surface by solvents, poor adhesion, plasticizer migration are but a few of them.

The author discusses in his paper lacquer formulation which give good performance on hard-to-coat plastics when applied by conventional spraying methods.

Use of Plastics in the Oil and Chemical Industry—*M. A. Mathews PhD Shell Petroleum Ltd. London England*

The rapid growth of the oil and chemical industry has created a great demand for construction material with special properties. Plastics in many instances can fill the bill and a great potential market is opening up.

The paper describes various types of plastics with regard to their properties, fabrication methods and price structure. Potential applications are mentioned in the field of oil drilling, refinery, tankers, chemical plant requirements and the distribution of oil products.

March, 1957

A new method for mixing and compounding of plastic materials in one operation—*Peter Pilz, Dipl. Phys. Henschel, GMBH, Kassel, Germany*

The mixing quality of the compounds used are of great importance in the processing of thermoplastic materials.

The author describes a new mixing system where the material is mixed in form of powder and fluidized through aeration. The fluidized powder can be stirred like any fluids and the consequent use of the "Whirl mixing" make it possible to simplify the mixing equipment and at the same time improve its quality.

February, 1957

Impact Testing of toughened Polystyrenes—*G. Hulse and W. Taylor, Monsanot Chem. Fulmer Slough Engl.*

While many techniques have been devised to test the ability of toughened Polystyrene moldings to take the punishment of general service, most molders agree that what is needed is an impact test, easy to operate and clear in its interpretation. One difficulty inherent in all test methods is the choice of a piece of such a measured strength that it is known as a property of the material and not of the test piece. Molecular orientation seems to be the villain that obscures the true result of the test.

The authors are using the Izod test as a base for their observations and a technique is described by which the basic property of the material can be clearly calculated without interference from the special properties of the testpiece.

Infrared Spectroscopy as an aid for the identification and manufacture of Polymer compounds—*Bertil Sjoberg. Ph.D. Skoghallsverken, Skoghall, Sweden*

Infra red Spectroscopy is a source of important information on the structure of polymers and can extensively be used for determination of molecular weights. Polymers can be identified by characteristic groups which can be checked quantitatively as well as qualitatively. Infra red Spectroscopy is an important link in process control and the author proves convincingly that the manufacturer has an important tool and valuable aid in the analysis and process of his product.

Heat resistant Polyester and Phenolic Laminates for Aircraft—*L. S. Shephard, Chief chemist, Malmo Aircraft Ind. Malmo Sweden*

The paper discusses the Temperature problem created by high speed flying, its possibilities for the near future, and the role that polyester reinforced glass fibre plays in the resistance against these high surface temperatures. Properties of these materials, production techniques and quality control techniques are mentioned in detail and the author uses tables and drawings to illustrate his points. Reference is also made to the combination of these materials with metal and best ways to utilize the thermal insulating qualities of these laminates are discussed.

November, 1956

Hinges for Plastic Containers—*W. Bruce Brown*

Drawings and pictures of misc. hinges are shown and its mounting techniques are discussed in detail. The materials used are mostly different types of metal and molded sections in the case of the so-called captive hinge. Of interest for manufacturers of rigid boxes and containers.

Non toxic stabilizers and their potential application in the Scandinavian Vinyl Industry—*H. Verity Smith, Pure Chemicals Ltd. Kirby Ind. Estate Liverpool, England*

Difficulty from the health point of view has retarded the use and development of vinyl plastics in the processing, handling and packaging of food stuffs in the Scandinavian countries.

A survey is conducted into non toxic stabilizers particularly in view of the development of two new stabilizers which have been approved by the FDA in the United States.

October, 1956

Methods to improve adhesion between Glasfibre and resin in reinforced Plastics—*Civ. Ing. Per Agren. Vasteras, Sweden*

To achieve a good bond between resin and reinforcing material presents a major difficulty in the production of glasfiber reinforced plastics. Owing to the smooth surface of the glasfiber a mechanical bond is hard to achieve. It is however possible to create a chemical adhesion by means of several chemical compounds and the author describes in length and detail this process. The article lists a variety of chemicals for that technique and discusses the development of glass polyester textiles for production of weaving yarns in that connection.

Polymerization Process—*Sven Sonnerskog Ph D, A. B. Svenskt Konstsilke, Boras*

Highly technical article on the mechanics for the preparation of high polymers. Distinction is made between

1. Initiation by free radicals (photochem, and thermal excitation)
2. Initiation by ionic mechanisms
3. Synthesis by condensation polymerization

The author discusses these principles by means of many formulas and reference is also made to various existing literature on that subject. This is a dissertation of interest to the research chemist.

SECTION NEWS

Edited by
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190 Camden Road
Hamden, Connecticut

Cleveland-Akron

Polyethylene Conference

Robert L. Larsen

October 17th, 1957 came and along with it came 350 interested leaders in the plastic field, to see and hear more about the subject of "Polyethelene".

The morning session on the properties of polyethelene was well attended from the time of opening until the break for lunch. The speakers prepared their papers well as indicated by the questions from the floor following each speaker.

The afternoon session on the uses of this special plastic was equally as interesting and it would be impossible for this reporter to cover in any general way the papers given.

The program was well planned from the opening gun until the closing subject. Special mention should be given to Bill Messina, as chairman, for this conference for the orderly fashion it was handled. Ed Haskins of Zenith Plastics, our Secretary-Registrar, deserves a big hand for his untiring work for many weeks before the doors opened. Ralph Rohlfins, Monsanto, worked out the house arrangements and Bob Hershey, Hoover Co., spent much time and strain on the program. Many others of the local chapter assisted and all feel proud of the success of this meeting.

Long before the session had come to a close many were heard to express themselves for another meeting of this type and maybe the subject could be PVC. We'll just have to wait and see.

At the luncheon in the Rainbow Room, and while many were digesting the meat of the morning meeting, a different subject was presented. Mr. Bill Veeck, the Ambassador of Baseball, pointed out some of the ways not to win a pennant. His humor on the subject as well as his knowledge of the subject made for a very interesting 20 minute talk. Mr. Tom Bissell, SPE's new executive secretary was introduced and brought greetings from the national.

Naturally, immediately after the conference, those most concerned said never again, for it is a lot of work; but in a few weeks these same individuals will be on the floor at the local meeting and working again for some means to further this great industry.

With such a field—who knows what will be next.

The largest crowd to attend a regular meeting turned out on Nov. 11th, to hear L. (Larry) Ulmschneider, Eastman Kodak Company talk on "Automatic Injection Molding and Heater Design." The attendance numbered about 125 and overflowed into the main dining room of the Spanish Tavern in Brecksville.

Molders, builders, design engineers and representatives were all present to help make for a good night. Immediately following the dinner Pres. Ed. Campi called for reports from committeemen and Board Officers. Bill Messina of Bakelite reported on the Polyethelene Symposium and reported many interesting facts gained from this experience which should surely be helpful at the next meeting of this type. Treasurer, Ken Keller, reported the meeting a financial success.

Our speaker, Larry Ulmschneider, discussed the various procedures concerned for the successful operation on automatic molding and further amplified his paper by showing a film on the operation methods as used by Eastman Kodak Co. Exact (on the nose) specs are necessary throughout for proper automatic injection molding. This is true for mold design, temperature, timing and material used. Exacting inspection procedure as a follow up on the above "On The Nose" limits determine the success of quality and products. The film showed one man operating two and three automatic machines and separating the various parts for assembly and returning rejects to the press.

January meeting should be of interest for the subject will be:

"Vacuum Forming vs Injection Molding."

This paper will be given by R. L. Lee, Dow Chemical Co. "Opportunity is Dead," will be an added feature talk for the January meeting.

"Recent Developments in Extrusion Technology" by R. D. Sackett of Monsanto Chemical Co., an interesting subject is on the program for Feb.

Southern Cal.

Polyurethane Developments

John A. Stahmann

The November 7th meeting of the Southern California Section was addressed by Mr. R. C. Burch of the Mobay Chemical Company. During his work at their Development Department in St. Louis, Missouri, Mr. Burck has been associated with many advancements in this field.

Urethanes are prepared through the reaction of an alcohol with an isocyanate followed by a molecular rearrangement. With polyfunctional molecules, polyurethanes or polyisocyanates are produced. The basic reaction was studied some hundred years ago; the polymerization reaction was reported by Bayer during the 1930's. Polyester groups in the formulation have been extensively used by the Germans.

The basic isocyanate building blocks include toluene diisocyanates, and diphenylmethane diisocyanate. Hydroxyl groups give an urethane linkage while carboxyl groups give an amide linkage.

Foams are made in two ways. The first is the "one shot" system where all the ingredients such as accelerators, stabilizers, water, and esters are mixed and allowed to foam in place. The presence of large amounts of carboxyl groups or water causes the release of carbon dioxide, which results in the foamed product. The second method of manufacture of foams makes use of prepolymers with free isocyanate groups. This is continually mixed and poured upon a uniform slab in a mold bed. Slabs made in this manner are usually 8-10 inches thick, although thicker runs may be made.

By controlling the cross linking of diisocyanates and linear polyesters give urethane rubbers having excellent tensile strength and good abrasion resistance. In production the raw materials must be kept free of water, so either a vacuum kettle must be used to remove the water or prepolymers made which are subsequently cross linked.

Coatings must be kept water free. They display excellent adhesion with resistance to chemicals and abrasion. Similarly, the polyurethanes are used as adhesives for polyesters and rubber. Unfortunately, they begin to lose strength at 180° F.

Binghamton

Shrinkage of Thermosets

L. N. Chellis

Sixty-seven members and guests of the Binghamton Section met for a dinner meeting at the Vestal Steak House on November 21, 1957. Mr. Emery Slaght was presiding Chairman for the meeting.

Guests included Frank Donahue and George Hill of Monsanto Chemical Company, Cris Groos, Bill Guiseppi, Frank O'Halloran and Bill Post of Boonton Molding Company, Bill Mazar of Link Aviation, Inc., and Les Mosher, John MacGuffie and Jack Daut of IBM Corporation.

Announcement was made of the election of our new Board of Directors. Elected for three-year terms were Leonard Wheeler—American Plastics Company, Joseph Venne—IBM Corporation, and Thomas Davies—D. S. W. Tool Company.

Frank Reynolds, IBM, Felix Aimonetti, Link Aeronautical Corporation, and Leroy Chellis, IBM, were elected to two-year terms.

Jack Gwyn, Consolidated Molded Products Company, Leo Pranitis, Endicott-Johnson Corporation, and Emery Slaght, Stanley Chemical Company, were elected for a one-year term.

Our National Councilman, Frank Reynolds, was re-elected.

The officers and committeemen for 1958 are as follows.

President—Emery Slaght; Vice President—Leroy Chellis; Secretary—Leo Prantis; Treasurer—Felix Aimonetti.

Program Chairman—George Macindoe, Consolidated Molded Products. Ass't. Chairman—Leonard Wheeler, American Plastics Company.

Membership and Credentials—Jack McLaughlin, American Cyanamid Company. Ass't. Chairman—William Falk, Insulating Fabricators, Inc.

House Chairman—Vince Coppola, IBM Corporation. Ass't. Chairman—Milt Yurecka, Endicott-Johnson Corporation.

Publicity Chairman — Werner Schink, Ozalid Corporation. Ass't Chairman — George Puderbaugh, Consolidated Molded Products Co.

Our sincere appreciation goes to Wilbur Kupfrian, Otis Farnam and Jarvis Dew, the directors who were retired. These men were instrumental in forming the new section and contributed to our success in becoming well-established during our first year.

The speaker for the evening was Mr. A. J. Guzzetti, Development Department, Bakelite Corporation. His subject was "Shrinkage of Thermosets".

Mr. Guzzetti discussed the mechanisms by which molding shrinkage occurs. The three mechanisms are thermal contraction (a function of ejection temperature and the coefficient of linear expansion of the material), elastic recovery, and plastic deformation. The effect of molding variables such as mold temperature, preheat temperature, cure time, pressure, ejection time, and cooling rate were shown graphically by means of slides.

In addition to molding variables, the effects of material and part design were discussed in some detail.

It was concluded that control of molded dimensions is a joint responsibility of the material manufacturer, the mold designer and the molder.

The Binghamton Section did not meet in December due to the Christmas holiday. Our January speaker will be Mr. Joseph Grenier, Protective Closures Company, Inc., who will discuss "Practical Hot Runner Molds".

New York

Standards Needed In Reinforced Area

Malcolm Riley

After a joint dinner with the New York and Newark Sections at the Governor Clinton in New York on November 20, the Reinforced Group met to hear William J. Eakins, Consulting Engineer with DeBell & Richardson enter a convincing plea for standards in reinforced plastics. Mr. Eakins pointed out that the reinforced plastics industry has reached a plateau in development. The many variables inherent in the materials and processes which go into the manufacture of reinforced plastics parts have made it extremely difficult to reproduce dependable quality from part to part.

The cause of the problems associated with both resin and reinforcement, according to Mr. Eakins is that we have no truly uniform standard materials or testing procedures on which the shortcomings of reinforced plastics can be examined quantitatively rather than qualitatively. We must create a completely uniform glass fabric material which can be made in an analytically reproducible manner. And at the same time, we must develop a standard resin which has reproducible characteristics over extended periods of time. Combining these standards with a detailed and analytical test method, will provide a start from which we will be able to compare all available raw materials used in reinforced plastics to a common base. Also, we will be able to compare various techniques and processes against this common base.

An important problem in the industry is the lack of technically trained personnel. Personnel must be technically educated and taught how to use their education. Another lack is fundamental knowledge, from the molecular level on up, as to the basic physics of lamination.

Mr. Eakins then pointed out the results of work done at his company under contract with the Navy to develop a reproducible quality glass cloth. This was produced under a closely controlled process. Results of tests made on laminates laid up with this cloth showed a much more consistent resin content with more constant specific gravity than any others prepared with conventional reinforcements. In order to fully determine the validity of using such cloth, Mr. Eakins' company is supplying this "controlled process" fabric in a 181 weave with a Volan A finish to processors who agree to supply his company with results of a comparison between this fabric and conventional fabrics now obtainable. The speaker described this development as the first step in getting down to fundamentals in trying to find out the effect of improving glass evenness on characteristics of reinforced plastics laminates.

Detroit

Reinforced Group Begins New Series

W. A. Stark

The Reinforced Plastics Group of the Detroit Section has begun a new series of programs following the success of last year's meetings. To date papers were given by R. Rockwood of Barrett Division of Allied Chemical on "Application of Plastics," George Smead, Libby-Owens-Ford Fiberglass and "Glass Fibers," Ken Hoffman, Dow Chemical on "Finishes for Fibrous Glass," C. Jack Meeske, Reichhold Chemicals on "Poyester and Alkyd Resins," and W. Simpson, Ferro Corporation on "Pigment Dispersions for Reinforcing Resins."

Future subjects announced are "Resins for Tooling," "Surface Coating and Conditions to Weathering of Laminates," and "Foaming Resins."

The group meets every fourth Monday of the month, October through April. This year there were no separate meetings in December or January because of the National S.P.E. meeting in Detroit.

Officers of the group are George Wadtke, Chairman; Duey Hansen, Vice Chairman; Dr. C. J. Fitzgerald, Secretary; Travis Meister, Secretary, Walter M. Stark, Program Chairman.

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Philadelphia

Advances Noted In Phenolic Resins

E. G. Schwab

The joint meeting of the Philadelphia Sections of SPE-SPI was held on November 26, 1957 at the Franklin Institute. Prior to the meeting a dinner was enjoyed by members and guests in the Franklin Room of the Institute. We were very fortunate to have as speaker for the evening Mr. Herbert R. Clark, technical representative and Philadelphia office manager for the Bakelite Company. Mr. Clark, a member of this section for many years, spoke on a remarkable advance in phenolic materials by Bakelite, namely BMM-7000 Black 25 and Brown 15. According to Mr. Clark, there has never before been a phenolic material on the market quite like BMM-7000. It has the fastest cure speed and yet though seemingly contradictory, it has a wide molding latitude and a fast mold closing rate. These characteristics plus fast electronic preheating combine to give the fastest cycles yet with phenolic molding material.

It was pointed out that the pressure of consistently rising cost has placed greater and greater emphasis on getting the utmost in efficiency and economy out of any molding operation. Reductions in cure time of up to 50 per cent made possible by this new two-step, extra fast general purpose material has presented a new opportunity to reduce cost and increase productivity.

Slides were used in the program to illustrate laboratory test results. Comparisons were made with a typical two-step phenolic and a fast curing one-step type. It showed how the cure speed of BMM-7000 is faster and increases with increasing molding temperature. In the hot rigidity test, BMM-7000 once more proved superior. It enables the molder to pull parts out of the mold sooner, thereby reducing the time necessary to cure. However, because of the greater rigidity, smaller undercuts in the molded piece are required.

Molding latitude, which describes the range of temperature over which a material can be preheated and still fill the mold out at a given pressure, is another advantage of BMM-7000. The wide molding latitude curve of this new material makes it suitable for molding large pieces despite its remarkable fast cure speed. The electronic preheating rate is faster for BMM-7000 and, therefore, considerable less preheating than normal is required.

Another interesting point noted in the talk was the fact that this material allowed an unusually fast mold closing time. Considering the fast cure property it is strange to find BMM-7000 admirably suited for presses with fast or slow ram speeds. Good molding latitude is what makes this possible.

To insure faster cycles and optimum properties in finished pieces an approximate mold temperature of 340°F should be employed. If preforms are used, preform temperature of 230°F is suggested. In reference to degassing if it is necessary, field trials have established an earlier breathe to be preferable. Mr. Clark had samples of different moldings to show the reductions in cycles obtained using BMM-7000. A movie entitled "Design of Molded Phenolics" prepared by Bakelite Company was shown after the talk.

An excellent report was presented by Adolph Kissileff summarizing a recent survey conducted in the Philadelphia Section in reference to society activities and subject preference for future programs. Mr. Kissileff stated that the results were very helpful to the officers for planning next year's meeting. Forty percent of the section membership responded, which is considered very good. In Mr. Kissileff's analysis of the survey weak points in the preference of subject matter was evident among the survey participants. For instance, personnel rated last on the list of sixteen subjects regardless of the fact that it is of primary importance and concern to any company. This has been found to be a weak point of many company managements. Mr. Kissileff has spent many years as a management consultant and is qualified to discuss this subject. His remarks were well received and the members were requested to give the report considerable thought.

Program Chairman, Mr. Ed Fitzpatrick, announced a tentative program for 1958. The topics for the January and February meetings will be, "Color and Pigmentation for Thermoplastic Materials" and "Mold Design and Construction" respectively. A plant visitation will be scheduled for March or April. A complete schedule will be announced at a later date in the Section's News Letter.

Jack Lay passed away on November 2, 1957 at the age of 57. Mr. Lay was continuously employed by the A. H. Wirz Company, Chester, Pennsylvania since September 25, 1918.

He was a member of the Philadelphia Section of SPE approximately 10 years. Mr. Lay was an ardent golfer and fisherman and a person who enjoyed everything in which he participated. He had many friends, particularly in SPE.

Plastics in Airborne Electronics Book

A booklet containing reprints of the papers presented at the Southern California Regional Technical Conference on "Plastics for Airborne Electronics" is now available.

Copies may be obtained by sending a check for $3.00 to : Jack Fuller, c/o Hercules Powder Co., 3460 Wilshire Boulevard, Los Angeles 5, California.

Papers read at the conference covered the following subjects: Effects of Hardeners on the Electrical Properties of Reinforced Epoxy Laminates, Prediction of Mechanical Properties Through Determination of Electrical Properties of Plastics, as Influenced by Cure Conditions, Inorganic Plastics and Synthetic Mica for Electronic Systems, New Developments in Isocyanate Based Polymers, Silicones in Electric Systems, Encapsulations for Airborne Electronic Systems, Polyurethanes in Electronic Systems, Plastic Coatings, Quality Control of Printed Circuits for Airborne Electronic Systems, and Dielectric and Mechanical Properties of Antenna Window Materials for Elevated Temperature Use.

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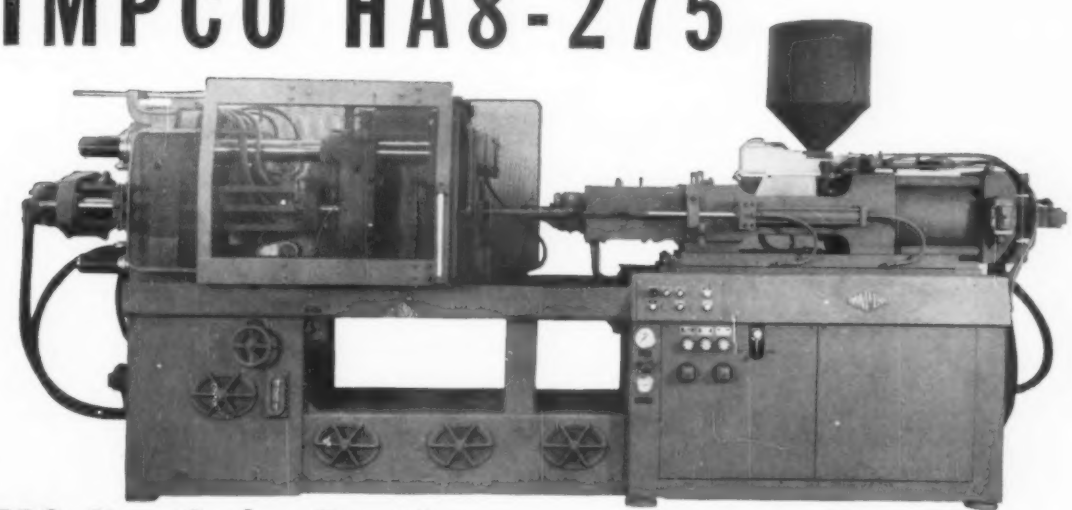

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Annual Party Held

C. Judd Holt, Jr.

More than one hundred members and guests attended the section's annual dinner-dance on December 6, at the Sheraton-Kimball Hotel in Springfield, Massachusetts.

The program included a cocktail hour, smorgasbord dinner and dancing. There were favors and door prizes for the ladies.

Chairman of the dinner-dance committee was Alvino Aliberti (A&M Tool & Die Company). He was assisted by Edward F. Duda (Holyoke Plastics Corporation), Herbert H. Hasenzahl (Pro-Phy-Lac-Tic Brush Company), Wesley L. Larson (DeBell and Richardson), Raymond A. Mazur (American Cyanamid Company), Robert R. Moyer (Monsanto Chemical Company) and Armand Vallieres (Pro-Phy-Lac-Tic Brush Company).

Southern

Nylon History And Uses Told

E. O. Redwine and R. E. Welch

The regular meeting was held Monday night, November 18, in the Architects and Engineers Institute Building in Atlanta. In the absence of our president, Mr. Hart, the meeting was presided over by Mr. Veazey LeCraw.

Nominations were presented for the Board of Directors and four people will be elected by mailed ballots, before the next meeting in December.

Our speaker for the November meeting was Mr. Larry Gentile, of Spencer Chemical Company, Kansas City, Missouri. Mr. Gentile was introduced by Mr. Dick McAllister, and his topic was nylon 6. Mr. Gentile told us of the background of nylon, beginning with its development in 1932 by Dr. Carruthers of DuPont. In 1938, nylon was patented and one of the first uses was for tooth brush bristles. In 1941, nylon attracted nation-wide attention for its use for ladies hosery. From 1950 to 1957, the use of molding resin in this country increased from 2 to 20 million pounds annually.

There are several types of nylon being produced but Mr. Gentile's talk concerned mainly nylon 6, which is easier processed than some of the other types. Nylon 6 is mainly used in injection molding but extrusion is gaining rapidly.

Some typical end-use applications of injection molding, extrusion, and centrifugal casting, were shown — illustrating the many excellent physical properties nylon 6 possesses.

A considerable number of questions from the floor showed the extreme interest in nylon by those attending and was proof that this was one of the better programs we have had this year.

Toledo

Quality Control Demonstrated

R. E. Dunham

The regular meeting of the Toledo Section was held on November 19 at Harrison's Ranch House. After a short business meeting, Mr. Delmer C. Dagne, quality engineer of the Hoover Company, spoke on "Some Techniques of Quality Control."

Mr. Dagne opened his talk with a description of the importance of the science of quality control in the organization of the Hoover Company. Under the vice-president in charge of production, quality control enjoys the same level in the organization as the works manager has, and, therefore, has equal importance with the production unit. The quality control group divides into Line and Staff functions, with inspection as the Line activity including receiving, processing, finished goods, test, equipment, salvaging, and trouble shooting. Information secured by inspection is analyzed by the staff group which determines process capability and use, the inspection data for studying the status of quality of all ware.

Two main points, with regard to quality control, were emphasized by the speaker: use of the frequency distribution, and sampling. By examples and charts the speaker showed the usefulness of tabulating the frequency of occurrence of a property with respect to specifications in the manufacture of a part. This tool has been useful in checking plastic moldings. It is a simple technique which can be widely applied.

By means of the traditional bowl of beads and a sampling paddle, the speaker demonstrated the need for good sampling plans. With a 0.5 per cent quality level a sample of 150 was found to be adequate for 1600 parts, while with a 3.5 per cent quality level, 150 did not predict the quality of the lot so as to bring about the rejections justified.

An open discussion, particularly centered on the use of quality control in plastic operations at the Hoover Company, concluded the talk.

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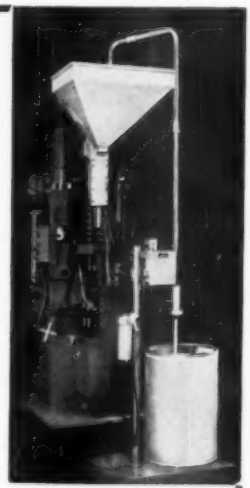

Model 512A
(Photo Courtesy Lester-Phoenix Inc.)

Need for Engineers . . .

(Continued from page 43)

way, much could be done to improve the public relations of the plastics industry. Perhaps the S.P.E. should cooperate with the universities in setting up courses in plastics or plastics engineering.

The challenge is there; a public relations job is needed. The industry must convince the young people of the great challenge and opportunity awaiting them in plastics. There would be no shortage of plastics engineers if this were truly understood. S.P.E. groups everywhere should arrange for speakers to visit high schools and universities. Films, panel discussions, all could be used to advantage. All could be part of an important public relations program to sell the plastics industry to today's youth—the potential plastics engineers of tomorrow. ★ ★

Printed Circuits . . .

(Continued from page 26)

laminates for this function is the area most immediately attractive, I don't believe it should even temporarily represent the limit of thinking, certainly not in the automotive field. The electrochemical processes have tended to work with laminates of phenolic, epoxy, fiberglass, melamine and so forth. The critical dielectric requirements of electronic design, as well as the introduction of the materials to liquids and corrosive atmospheres in processing, generally justifies the insulation that has been developed for the circuit trade. Many of these physical properties, however, are unnecessary in automotive application, particularly where the mechanical processes are used. In the interest of lower costs we have already used impregnated pulp stocks in some locations and upgrading this material slightly would open up many more areas.

Lowering the cost of stock is not the only approach. We badly need new characteristics in some materials only potentially useful at present. Thermoplastics in vacuum formed and injection molded shapes improved to stand processing heats would permit a combination of electrical and structural functions in many locations. Low-cost post-formed laminates may accomplish the same result. Base materials suitable for integration with plastic components by secondary molding also offer very attractive possibilities as conversion problems spread.

Adhesives Problem

The adhesive development for bonding circuit to base is a problem in plastics. In our adhesives using thermoplastic and thermosetting resins, we still lack adequate bond strength under all conditions. The uniformity of coating, the speed of the curing cycle, can be improved. The plastic adhesive will be subject to new environmental conditions as the use of printed circuitry spreads. More heat resistance, resistance to fumes of gas and oil in both adhesive and the insulator will be a must if the utilization of circuitry is to reach its full potential.

Plastic coating, sealing and encapsulating materials, laminating surfaces will all need further development as the volume needs of the automotive industry begin to bear on this new field.

The printed circuit is not likely to be the exception and resist the stimulus to expansion and progress that has driven every similar technology when the potential in automotive production became apparent. In this progress the plastics industry will be a major partner. ★★

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Higher Density . . .

(Continued from page 24)

be very worthwhile, and higher-density polyethylene pipe should enjoy a large cost advantage over such competitive materials as monel, stainless steel, and glass.

Wire

In the wire-coating field, interest has been aroused by the improved heat resistance and out-resistance of the higher-density polymers. Extrusion coating of wire has presented no real problems, but laboratory and field tests have shown some highly variable results. Short-term laboratory tests by the wire coaters are designed to eliminate obviously inferior materials. However, since the industry expects installations to stand up for something in the neighborhood of twenty years, field service trials are usually mandatory. The results of two years' work are far from conclusive, with excellent results in one case being cancelled out by failures in another. It appears that special formulations may be necessary and that the high-density polymers in their present commercial form may not be suitable.

Injection Molding

The bulk of the injection molding work with the higher-density polyethylenes has been based on melt indices of over 1.0 because of easy processing. For many jobs these higher melt index materials provide the required heat resistance, impact strength and structural stiffness. In the broad sense, these high-density polymers are competing with the cellulosics and the impact-type styrenics. In some special cases materials of less than 1.0 melt index are preferred because the improved strength and environmental crack resistance are of greater importance than processing ease.

Rapid injection into a cool mold will suppress crystallite growth and will produce parts of top quality. In fact, we have established that the use of a refrigerated mold (coolant at 20°F) makes possible the production of higher-density polyethylene parts which are malleable, whereas parts from a warm mold (same lot of material) may not display such extreme impact resistance.

Items which are being injection molded range from buckets to bottle caps which are ejected by stripping instead of unscrewing. The list includes such things as ball point pen cartridges, paint brush handles, lawn mower wheels, CO_2 fire extinguisher cones, and roller skate bushings. Each of these applications is obviously taking advantage of one or more of the basic properties of the high-density polymers, and each item represents sound engineering and logical material selection.

Conclusion

During the next year or two, plastic processors will undoubtedly see a wide variety of "new" materials as the producers of the higher-density polyethylenes begin offering modified types and special formulations. It is known that the addition of such things as polyisobutylene or various rubbers will prevent or retard spherulite formation and, to a certain degree, this effect can be observed as an increase in environmental crack resistance. This slight gain, however, may be accompanied by reductions in tensile properties and heat resistance, as well as by increased deformation under load. Some very worthwhile work has been done on physical mixes of higher-density and lower-density polymers. Most of the properties follow a definite relationship which is dependent upon the ratio of the components. It is not impossible that this may constitute a threat to the medium-density materials in some instances. Such compositions are most satisfactorily produced by hot melt mixing. Injection-molding of a dry mix of higher-and-lower pellets is often unsatisfactory, because of the possible "flotation" of the high-density pellets in the fluid stream of lower-density material. This is another case in which melt index figures cannot be taken at their face value.

Additions of long-chain hydrocarbon synthetic waxes will definitely improve moldability and surface quality, but will also lower tensile strength and impact strength, and will certainly raise the brittleness temperature.

The use of antioxidants is often desirable to protect the higher-density polyethylenes against oxidation breakdown or degration, and it is obvious that such anti oxidants should be non-fugitive, non-staining, and acceptable to FDA where required for food contact.

As a class, polyethylenes exhibit relatively poor light stability, and protection is essential if the product should be intended for outdoor service. Pigmentation is beneficial, with black furnishing far greater protection than colors. Producers are continuing their work on additives other than pigments for light stabilization.

In conclusion, it must be remembered that the lower, medium, and higher-density materials are all polyethylenes and, as such, display some common properties. They also display some striking differences. It is these differences which will minimize the competitive situation among the three basic types of polythylene and which will define the fields of usefulness for each type. ★ ★

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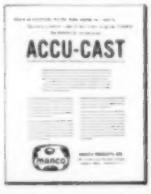

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Philadelphia

Visit of Management Teams To Foreign Countries Described

E. G. Schwab

The Philadelphia Section of SPE held a Management Night jointly with the local SPI Section on October 22, 1957 at the Franklin Institute, 20th & Parkway, Philadelphia, Pa. We were very pleased to have Mr. Saul M. Silverstein, President of Rogers Corporation as our guest speaker. In presenting his subject Mr. Silverstein described the activities of American Management Teams that have visited all of the Western European countries as well as Turkey, Israel, Japan, Chile and Mexico. These trips are part of the United States Technical Assistance Program originally developed under the Marshall Plan. The agencies that have directed this work have been the ECA, MSA, FOA and now the ICA.

To date some thirty teams comprising one hundred and fifty managers have carried out these missions. Briefly these activities involve sharing experience with managers over seas in an effort to increase industrial production. Considerable interest was developed in the area of marketing because increased consumption is obviously the key to expanding economy. Hence, the word "marketivity" was coined to develop its interrelationship with "productivity". Above all, emphasis was put on human relations as the key to the entire management problems. A very active question and answer period followed Mr. Silverstein's talk.

The program for this meeting was prepared to cater mostly to the management of companies interested in plastics. It is a way of showing management what SPE-SPI can do to enable their companies to keep abreast of current developments in the plastic field.

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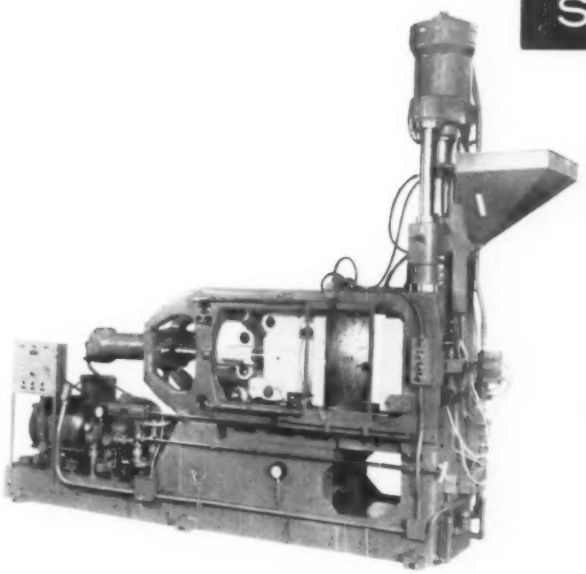

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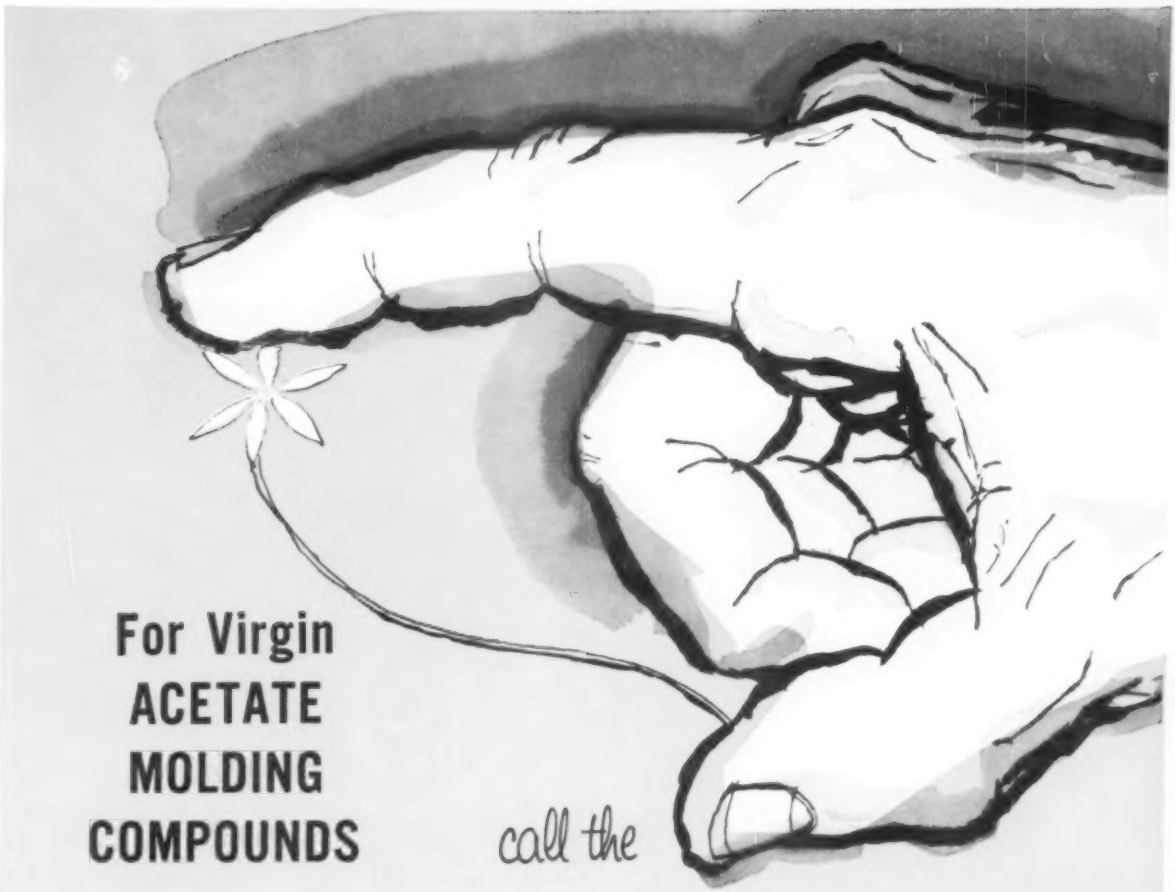

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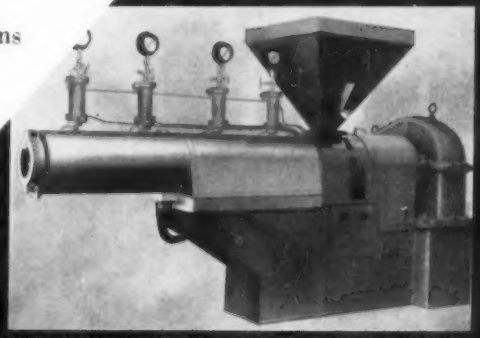

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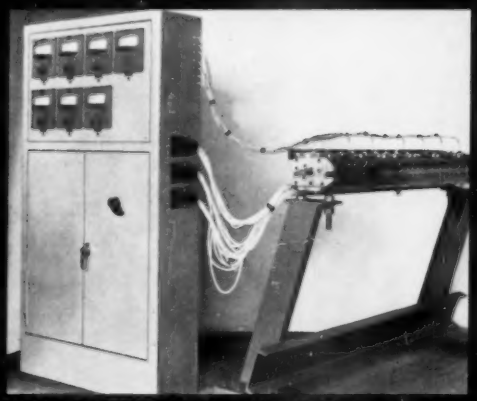

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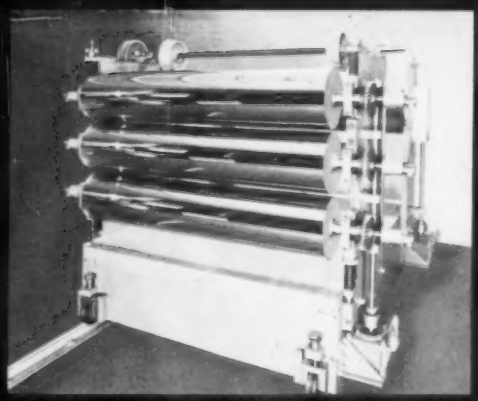

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